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Using interactive digital media to engage children on the autistic spectrum

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Using interactive digital media to engage children on the autistic spectrum

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Abstract

The incidence of autism is increasing in the U.K., with as many as 1% of children now thought to be affected by an autistic spectrum disorder (ASD). This research explores the potential of emerging interactive digital media to engage children affected by an ASD, and the development of design strategies for future professional work in this field.

This is accomplished through a literature and state of the art review, and by working alongside families and professionals involved in the provision of care for children with an ASD. As a a result of this process new artefacts have been created, alongside a design methodology for future work.

The research reveals the need for tailorable low arousal sensory environments within mainstream schools to meet the needs of certain members of the pupil population and demonstrates how interactive digital media can be incorporated into such spaces as part of an holistic approach to a child's school experience. Using digital media modules trained professionals can work with the child, using the media as a point of engagement.

The need to take a holistic approach to the design and understanding of such interventions is examined in the light of the Hexagon Spindle model of educational ergonomics developed by Benedyk et al. (2009).

The action research and reflective practice approaches adopted have led to a recognition that design in this field has a number of influences beyond purely user centred design. To account for this a new model of community centred design has been developed.

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Part 1

Introduction

This first part introduces the research and provides a review of the literature that has informed the work. This is covered in chapters 1, 2 and 3. part 2 of the research covers chapters 4,5,6,7 and 8 and discusses Project Spectrum, a case study which demonstrates the practical application of the research and the emergence of new artefacts and design models as a result.

Supporting audio visual (AV) material

Included with the research is a digital PDF document containing video and images that illustrate much of the work referred to in the text. This has been included to more adequately describe the visual and interactive nature of this work. The document is divided into two sections; 'Inspirations', which illustrates many of the works created by other artists and designers which have inspired the work completed during this research; and 'Prototypes', which illustrates the work created during this research, some of which featured in the final delivery and evaluation of Project Spectrum.

The document also includes interviews with members of the community who helped to inform and evaluate the design of the artefacts produced during the research. These should be viewed as evidencing the success of the artefacts (modules) in stimulating the engagement of children with an ASD and meeting the main aim of this research.

When a piece of work illustrated in the supporting AV material is referred to in the text, it is followed by the corresponding page number in the PDF document. ie:

"Works of art such as 'Text Rain' (Utterback and Achituv, 1999) (See supporting AV material p.2) demonstrated how an audience could have an immersive and playful relationship with a digitally manufactured and delivered work".

In this example the reader will find a video of the work Text Rain on page 2 of the supporting audio visual PDF document.

In order to successfully view the PDF document on either Windows or Macintosh systems, the reader will need to have Acrobat Reader version 9 or higher (available from http://get.adobe.com/reader/), and Quicktime Player version 7.6 or higher (available from http://www.apple.com/quicktime/download/). (Linux based systems may work but are not supported.) The installers for these have been included on the disc. When opening the PDF file please ensure that you do so using the latest version of Adobe Reader.

All images and videos have been included in the supporting AV material with the permission of the authors and participants where possible. All figures used in this Ph.D. are the original work of the author or have been reproduced with reference to their source. All images, videos and figures are used under the understanding of the 1988 UK Designs and Patents Act which states that fair dealing with a literary, dramatic, musical or artistic work for the purposes of research or private study, criticism or review, or for the purpose of reporting current events, does not infringe any copyright in the work, or the typographic arrangement of a published edition.

Chapter 1 - Introducing the research

This chapter provides an introduction to the research. It gives the background and context to the work followed by the aims, objectives and rationale. This is followed by a description of the research process, the structure of the thesis and finally the proposed contributions to knowledge.

1.1 Introduction

The prevalence of autism in the UK is increasing (Baird et al. 2006). As a practitioner working to develop new models of interaction with digital tools and digital media, it was brought to my attention that the work I was doing might have a significant impact on groups of children with special educational needs (SEN), and in particular those with the social difficulties associated with autistic spectrum disorders (ASD). Previously my work had been aimed at audiences who enjoyed playful interaction for its own sake, the sense of control and expression it gave them, and the reward they perceived through the response of the media to their actions and interactions. This had included collaborations with dancers, musicians, visual artists and generative artists to create experimental pieces that examined the nature of interactivity and performance. This work was inspired by the work of artists such as Golan Levin and Andrea Polli who explored the use of interactive technology within their practice.

It was during the presentation of one such experiment that I first met with Bob Burn (now at the Helen Hamlyn Centre) who was acting as an external examiner to my MA course in Design and Digital Media. Burn had been working extensively with children on the autistic spectrum in Holland as part of his LECA (Learning Environment for Children with Autism) (Burn 2005) project, and could see potential to develop my work for children with an ASD. He said of the work,

> "Your ideas and the potential for non key / mouse interfaces was exciting and well presented. Loads of applications within special needs worth working on and I'd be delighted to think that it may be possible to devise a specific project."

Following this initial discussion, I contacted a local school for children with Special Educational Needs (SEN) including ASD and having completed a CRB check, arranged to bring in some of my work to test with the children and measure their and their teacher's responses. Before going to the school, I tailored the imagery of the work to what I thought might be engaging and appropriate for the children. Although the school caters for young people aged between 2 to 19, I would be working with the younger end of this range and with a range of abilities. I spent one day at the school, and created a temporary installation which allowed me to share five examples of the work I was developing at that time. All of these responded to the movement of the participating child and returned visual and / or audio responses, in the hope that an interactive relationship of cause and effect with an overall sense of control would emerge for the child. (See supporting AV material p.16-17).

The feedback from this day, both through my own observations and from those of staff members was very positive. Most of the children engaged with the digital media and interacted with it without prompting. Led by the more enthusiastic and outgoing children, a system of peer modeling emerged in which children followed each other to discover methods of interacting and observing responses from the media. Staff commented that the experience had been "useful for non-interactive youngsters", "a couple of the group wouldn't normally have engaged, so that proved its value". This together with more formal feedback suggesting how the work might be developed, where it could be delivered and how sessions could be better structured , encouraged me to believe that there was an exciting potential in further design and development for this audience, and that the rewards might be more significant for myself than my previous creative practice.

One year later (2003), following continued research and development and a series of exploratory projects, I was offered a studentship on an Arts and Humanities Research Council grant to research the use of digital technology environments to nurture engagement of children on the autistic spectrum (Project Spectrum), under the direction of Professor Andree Woodcock and Darryl Georgiou. The research team comprised of an expert in autism and social science methods (fellow PhD candidate Jacqui Jackson) and myself acting as designer of the environment and digital artefacts based on the requirements that emerged from Jackson's and my own work. The research documented in this thesis and the accompanying supporting audio visual document of practice, includes the research and development undertaken to fulfill the AHRC funded research, and indicates how subsequent practice built on the findings of 'Project Spectrum'.

1.2 Aims and objectives

The main aim of the research was to explore the use of interactive digital media to engage children on the autistic spectrum. This was broken down into the following objectives:

1. To understand the needs of children with an ASD, the range of the autistic spectrum, the challenges faced by individuals, schools, their families and support networks

2. To establish the benefits of current applications of interactive technology to this group through a state of the art review

3. To apply the understanding (from 1 and 2) to the development of a series of interactive digital media modules

4. To examine the effectiveness of the experiences from the perspectives of all stakeholders and apply this to future developments

5. To develop an effective design process which could lead to the creation of bespoke design for this user group (i.e. children with an ASD) through reflection in and on practice

The aims and objectives of Project Spectrum can be found on page 98. These share the same overall of aim as this PhD, but are more concerned with embedding the requirements into an environment for children with an ASD. The objectives of Project Spectrum were shared between myself and Jackson, whereas meeting the above objectives of this PhD is entirely my own work.

1.3 Rationale

Autism was first described in Kanner (1943) as "early infantile autism", the description of autism was later broadened by Wing and Gould (1979) to include a spectrum of children with special needs. Their definition included a triad of impairments which described children who had difficulties with social communication, social interaction and social imagination. Wing (1980) also described Asperger's syndrome as part of the autistic spectrum, a condition first described as 'autistic psychopathy' by Asperger (1944). Further diagnostic criteria for autism include difficulty with movement and coordination, executive function, theory of mind, central coherence and repetitive behaviour.

The cause of autism is not known, though it is thought to be linked to genetics (Bailey et al. 1995). In the U.K. there has been an increase in the prevalence of ASD (Baird et al. 2006). This may indicate either or both an increase in the incidence of autism and a broadening in the diagnostic criteria for the ascertainment of pervasive developmental disorders. Autism is associated with several co-morbid conditions including attention deficit and attention deficit hyperactive disorders (ADD and ADHD), dyslexia, dyspraxia and sensory integration dysfunction.

There is no 'cure' for autism and indeed it is argued that it should not be considered as an illness but rather as 'a way of being' (Harmon, 2004). There are however a range of interventions available to children on the autistic spectrum, and it is generally thought that early intervention is the best route to improving an individual's life experiences (Baron-Cohen, 2004). These interventions include behavioural, sensory and educational approaches. No one intervention has been found to be appropriate for all children on the spectrum, and the effectiveness and length of the intervention varies from one individual to the next.

"The Royal Society of Medicine Forum on Learning Disability was an exploration of the possibilities for enabling creativity with people with learning disabilities. Virtually absent from the forum was any mention of ICT and its benefits … Although ICT was not directly discussed, it seems clear that it is an area requiring debate."

Ben Williamson, Futurelab, 2002

Today young people in the U.K. are growing up in a digital landscape (Prensky, 2001). They are described as 'digital natives', whereas those born before the ubiquity of digital devices are referred to as 'digital immigrants'. Prensky argues that children today are fundamentally different in the way they access and learn information and in the way they interact with the world because of their experiences with digital technologies. In today's schools it may be argued that in some cases children are the experts when it comes to using digital tools, and the teachers need to learn new ways of working (Hasna 2009).

Computers have been argued to be an ideal tool to promote communication, sociability, creativity and playfulness amongst children on the autistic spectrum (Lesser and Murray, 2007). The computer can be seen to 'level the playing field' for the child, as communicating through it removes many of the social difficulties associated with ASD (See supporting AV material p.12 (Carly's Story)). Providing devices for communication such as the keyboard, presenting a highly visual tool through the monitor and allowing for remote contact through computer networks are all ideal for many children with an ASD. This provision of methods to circumvent the difficulties of ASD points towards greater inclusion of children on the autistic spectrum within schools and later within workplaces and social networks. If a digital revolution is taking place within the U.K.'s schools, then it is in the interest of those concerned with ASD to embrace digital technology and help to shape a new and inclusive educational experience for children.

In the U.K. computers and digital tools are now affordable resources for schools and homes. Recent years have seen an increase in the available processing power and range of applications available to everyday computer users. Designers are now starting to appropriate this new technology into original suggestions for new ways of interacting with digital media. No longer restricted to the traditional mouse keyboard interface, experiments are being made to interact through movement and gesture, vocalisation and verbalisation as well as through a range of different haptic and tactile interfaces. Likewise computer software has adapted to support this work, resulting in a range of available applications that allow designers to create bespoke interactive prototypes without necessarily having to develop their own software platform. A community of new practitioners has emerged both in the academic and commercial fields, who are exploring the field of interactive digital media within a wide range of contexts and audiences. (Candy and Edmonds, 2007)

This research aims to explore the use of new interactive technologies with children on the autistic spectrum. It is felt that given their affinity with computer controlled systems, and the diverse range of multi-modal interactions and media available, it is possible to create original interactive experiences that are tailored towards the children; that will significantly engage them; and that will complement existing interventions. As part of this research an environment has been developed in which to deliver the interactive experiences. Whilst many schools for children with special educational needs (SEN) currently have Snoezelen (Hulsegge and Verheul 1987) style multi sensory environments available to their pupils, very little research has been done into their efficacy with children on the autistic spectrum (Jackson 2009). The evaluation of Project Spectrum aimed to further knowledge in this field, particularly regarding the use of digital media as sensory stimuli.

Taking a user centred design approach (Norman, 1988) as a starting point, a design methodology has evolved alongside prototype development to form a creative design cycle. This commenced with information on ASD provided by Jackson as part of Project Spectrum (PS) which provided the requirements for a set of prototype artefacts. This information was rapidly supplemented by first hand experience and knowledge derived from taking an action research (Lewin, 1946) approach to work alongside the children, parents and teachers during the design, development and iterative testing of artefacts, which in turn gave rise to new ideas and approaches. These are subsumed into the design methodology creating an original way of working within this field.

Importantly the research also examines how such technology can be brought into schools and incorporated into everyday school experience; how teachers and support staff can inform the design process and integrate the technology into their curricular duties and how the technology is accessed by school children, their teachers and support staff. This involves discussion of the inclusive policy taken by many schools toward pupils with an ASD and consideration of design models that take a holistic view of the child's school experience.

By discussing how the knowledge generated during Project Spectrum has been shared amongst various stakeholders, the research shows how a community approach to design can lead to more successful products with real world application.

1.4 Outline of research stages

The research presented in this thesis involved five key stages.

1.) Identification of a potential benefit

2.) Practice based research

3.) The emerging artefact

4.) Evaluation

5.) Knowledge transfer

1.) Identification of a potential benefit

All the research stems from the belief that children on the autistic spectrum might derive benefit from using new interactive digital technologies. This hypothesis was confirmed through:

i) A review of literature related to ASD,

ii) A state of the art review of interactive digital technologies,

iii) Observations of children with ASD in classroom, sensory rooms and at play,

iv) Interviews with parents, teachers, support workers, and where possible with children,

v) Interviews with designers and related practitioners working in this and related fields

2.) Practice based research and reflection

Taking a user centred design approach, existing examples of practice were tested with the community. In reflection during and after these sessions, new prototypes were developed, informed by ideas emerging from the initial stage of research detailed above and user testing. This iterative process involved a high degree of collaboration and joint reflection, and allowed for spontaneous development to occur at any stage of the process.

3.) The emerging artefact

Following the experimental phase of development a first iteration of a 'finished' artefact emerged which built upon the findings of the previous research.

4.) Evaluation

The emerging artefact was evaluated through

(i) observation of controlled sessions at the school where children were invited to have a short lesson in the room

(ii) interviews and questionnaires with all stakeholders (the headmistress, teachers, teaching assistants and parents).

5.) Reflection and transference of knowledge

Through a process of reflection in and on the evaluation of the artefact, knowledge obtained through the above research phases was recycled into further design projects, conference papers and online resources as well as being disseminated back into the community. This included developing further projects as part of my own ongoing practice, in which I employed the research techniques developed in this work, continued to work with children affected by autism and developed further examples of interactive digital media.

1.5 Organisation of the thesis

This thesis is divided into two parts. The first contains chapters 1 to 3 and provides an introduction to the research and a review of the literature and state of the art that have informed the research. The second contains chapters 4 to 8, which discuss the development of Project Spectrum from eliciting the user requirements, through the design and build of the interactive modules and low sensory environment, to its evaluation and findings. There now follows a brief summary of each chapter:

In Part 1:

Chapter 1 provides an introduction to the thesis, its aims and objectives and rationale. It outlines the stages of the research, the structure of the thesis and the contributions to knowledge.

Chapter 2 provides a review of the literature and artefacts that inform the inquiry of the research. The topics included are:

i) Autism, co morbid associations and interventions for autism,

ii) Interactive digital media including that used with children with additional needs including ASD,

iii) The use of interactive computer vision systems for media art and its appropriation for use with children with additional needs including ASD

Chapter 3 discusses the literature that has informed the design process used when developing Project Spectrum. This includes:

i) User Centred Design

ii) The Hexagon Spindle model or ergonomics applied to educational environments

iii) Action research and reflective practice

iv) Reflective Practice

Then in Part 2:

Chapter 4 discusses how I elicited the requirements that would inform the design of the artefacts. This includes the findings of a co researcher as well as the action research and reflection I undertook amongst a community of potential users of the environment and modules.

Chapter 5 provides detail on how the interactive digital modules were designed in response to the elicited requirements

Chapter 6 illustrates how the low sensory environment was developed within an existing school, and how the technology and modules were included within it.

Chapter 7 discusses the evaluation of the environment and the interactive modules. This includes the criteria for evaluation, the method used and the emerging findings.

Chapter 8 discusses the research. It summarises the findings; the extent to which the aims and objectives have been met; and how the case study serves to illustrate and explore the themes detailed in the introduction. It discusses the limitations of the research and the contributions made to knowledge in the thesis. It then outlines future work in this field.

1.6 Proposed contributions to knowledge

It will be argued that the following contributions to knowledge have been made

1.) That interactive digital media can engage children on the autistic spectrum and can be used as part of an holistic approach to addressing their requirements. Evidence will be put forward as to how this has been shown in the case study Project Spectrum, and the strategies used to support this.

2.) That a facilitator who understands the needs of children with ASD should consistently work with children when using the digital media, in order to best develop their engagement by tailoring the system and mediating their experience appropriately.

3.) That low arousal 'sensory classrooms' such as that presented in Project Spectrum are a valuable resource within a mainstream school and can be created affordably with readily available resources. These environments can be used to deliver interactive digital media such as that created for Project Spectrum.

4.) That a community centred design process has been developed and demonstrated in Project Spectrum. This process allows designers to engage with their target users and various other communities who are experts in their field, and to act as a disseminator of this knowledge between the communities. This process combines user centred design with action research and reflective process within iterative cycles.

5.) A series of requirements for design projects involving children on the autistic spectrum, and how these can be mapped onto interactive digital media has been presented. Project Spectrum offers examples of this application and suggests how this work could be extended in the future.

1.7 Conclusion

This chapter has introduced the thesis. It has given a background and context to the work and detailed its aims and objectives. It has provided a rationale for the work undertaken, outlined the stages of the research and how these have been mapped onto the thesis. Additionally contributions to knowledge have been identified. The following chapter presents a more detailed rationale for the research through a literature and state of the art review. These consider the nature of autism and the interventions available for children on the autistic spectrum; the state of interactive digital media and its use with children on the autistic spectrum; and the design methodologies used to create interactive digital media for the community.

Chapter 2 - Literature review part 1: Autism and interactive technology

Introduction

This chapter is the first part of the literature and state of the art review. It includes a discussion of the literature that has informed this research on the subject of autism, its co-morbid conditions and existing interventions used with children on the autistic spectrum. It includes a review of interactive technology using computer vision, and discusses the use of this technology with children with special and additional needs. The following chapter (3) will conclude the review by discussing the design practice that has informed this research.

In order to begin designing prototypes for children on the autistic spectrum it is important to have both a theoretical and working knowledge of the condition. The first can be gathered through a review of the literature which is detailed below. The second must be achieved by developing a network of contacts within the community, consisting of parents, carers and educators as well as the children themselves and through them gaining a firsthand understanding of the world of a child with autism. This dual approach of literature and action research provided a level of understanding that enabled requirements to be generated and productive interactions with children to take place. This met a primary objective of this research.

The literature provided an overview of the autistic condition and how it is experienced, as well as knowledge of various theories and practices that seek to explain and address it. This knowledge facilitated work in the field, providing me with a starting point with which to commence further research. Familiarization with the relevant terminology allowed me to perform field research and develop ongoing dialogues with the community. When first encountering a child on the autistic spectrum the literature review provided a theoretical expectancy and understanding of the child's experience which could then be modified and matured through prolonged contact with the child and their community. In this way my subjective observations and individual skill could be combined with findings from the literature and the knowledge of the community to produce new artefacts.

The first section of the literature review gives an historical introduction to autism, detailing when, how and by whom it was first diagnosed and how it is understood currently. It gives a description of the triad of impairments and additional diagnostic criteria. It discusses the co-morbid conditions that are often associated with autism and then describes the rise in incidence of autism in the UK.

The second section of the literature review describes several of the interventions that are available to children on the autistic spectrum. A designer working in this field needs to be aware of the other facilities and programs already being offered to children. It may be that ideas and principles can be incorporated into designs, and that existing solutions can be augmented. It also provides background on the community and the resources currently offered to them.

Following this, the third section of the review, provides a discussion on the use of computers and computer controlled systems with children with ASD. This is fundamental background for the designer working with digital technology for children on the autistic spectrum and corresponds to one of the objectives of this research. It continues the theme of interventions and leads into the next part of the chapter which discusses the use of digital and computer controlled technology.

2.1 Autism

Autism is a lifelong developmental disorder that occurs across a continuum referred to as the autistic spectrum. It was first described by Leo Kanner (1943) as "early infantile autism", referring to behaviours such as obsessiveness, echolalia (repeating words or phrases learned from other people), and extreme aloneness in which children show an isolation from the world around them. He considered the condition to be genetic in origin as the behaviours are normally manifest from early infancy and there tended to be a family history of obsessiveness. However the opinion of the time was that bad parenting was responsible, and autism was thought of as an emotional disorder.

A year later Hans Asperger (1944) wrote a paper where he identified a pattern of behaviour which he termed as 'autistic psychopathy'. Nowadays this is known as Asperger's syndrome. Like Kanner, he noted that children affected by the disorder had difficulty integrating socially and that they lacked non verbal communication skills, did not empathise with their peer group and could be quite clumsy. Asperger's syndrome does not necessarily have the same lack or delay in language as Kanner's autism.

Today autistic spectrum disorder (ASD) is described as a pervasive developmental disorder (PDD) and both descriptions have become synonymous for the condition (Baird et al. 2003), although ASD is more commonly used and understood amongst parents and professionals. Despite now being recognised as having an organic basis, autism cannot be biologically tested for and diagnosis is achieved by examining the history and development of the individual, and observing their behaviour in a variety of settings. The criteria used for diagnosis has been arrived at through consensus and has been refined over time to account for the complexity of the condition and trends in scientific thought.

The symptoms exhibited by individuals vary, although they can be broadly categorised as falling within the 'triad of impairments', these being difficulty with (i) social interaction, (ii) social communication and (iii) social imagination. (NAS 2006)

(i) Social interaction is classified by activities such as turn taking and sharing, as well as appropriate social behaviour. Typically those with an ASD may appear detached or aloof.

(ii) Social communication considers expressive and receptive language skills as well as being able to understand body language, facial expressions or tone of voice. Again difficulty with this can lead to an individual being 'apart' from everyday social behaviour.

(iii) Social imagination refers to being able to partake in imaginative play and to transfer skills between activities. Difficulty with this can lead to rigid behaviour including copying others.

In addition to the triad of impairments, diagnostic criteria may also include difficulty with (i) movement and coordination, (ii) repetitive behaviour, (iii) executive function, (iv) theory of mind and (v) central coherence.

(i) Children on the autistic spectrum are often described as clumsy (Attwood 1997) and may have difficulties with both fine and gross motor skills. These may be experienced as difficulty with upper and lower limb coordination, catching or throwing objects, handwriting and keeping a rhythm (Manjinova and Prior, 1995).

(ii) Repetitive behaviour is a common attribute of children on the autistic spectrum (Turner, 1999). The reasons behind this are still unclear. However it should be noted that there is wide variety in the nature and manifestation of repetitive behaviour. It has been argued that such activity helps to reduce chronically high levels of arousal, and that engagement with the new and unfamiliar causes uncomfortable levels of arousal. As the behaviour often results in sensory stimulation it is also argued that it occurs for repeated sensory gratification. Furthermore it has been argued that the repetitive behaviour helps to reduce anxiety caused by not being able to understand the mental states of others, and the individual is able to partake in a familiar activity where they have control. Difficulty in executive function may also be a contributing factor and it may be that the individual cannot gain control of their behaviour.

(iii) Executive function is an umbrella term for functions such as planning, mental flexibility and inhibition (Rajendran and Mitchell, 2007). These functions require a disengagement from the immediate environment. To illustrate this: Planning requires an individual to be able to project the results of actions into the future in order to predict results and solve problems. Mental flexibility requires being able to understand the same item within a range of contexts or categories. For example a London bus would fall into both categories of transport and red. Inhibition is the ability to stop one input interfering with the understanding of another. This is traditionally tested by activities such as reading the names of colours written in different coloured inks and then naming the colour of the ink rather than the written word. Whether or not difficulty with executive dysfunction occurs in all cases of autism is currently unclear, although it has been found in many cases.

(iv) An impairment in theory of mind signifies that an individual cannot, or has difficulty with, acknowledging the mental states of others. This has been tested by enacting scenarios with puppets (Baron-Cohen et al. 1985) in which one puppet character is led to believe something that is not true. The participant will then be asked to make a judgement that requires them to infer the mental state of the puppet to give the correct answer. Further tests have been done on an individual's ability to tell a 'white' lie appropriate to a social situation and to measure if they understood when someone was 'pretending' (Happé, 1994). The results of these tests are inconclusive in that some children with ASD were able to pass the tests, and yet it is suspected that they may have done so without using a theory of mind function, but rather by being able to reduce situations to logical problems. More recent tests in which neurotypicals (Nts), and children on the autistic spectrum were shown silent animation (Klin, 2000) of moving geometrical shapes showed that whilst children with ASD described what they saw, the Nts attempted to ascribe it social meaning. In another study (Hirschfeld et al. 2007) it was found that despite failing theory of mind tasks, a group of children with ASD did use social stereotypes such as race and gender and it was hoped that this understanding of groups could provide a route into broader social understanding. Despite a common recognition that children with ASD do have difficulty relating to the mental states of others, a definition and theoretical explanation of Theory of Mind have yet to be agreed upon.

(v) Nts are described as having a drive for central coherence, meaning that they will try to see individual things as part of a whole. Individuals with ASD have shown a greater ability than Nts to identify simple shapes within complex figure (Happé, 1996) and this has supported the theory that they are more able to visually process local information (a detail or a part) than global information (the whole). This phenomenon is referred to as weak central coherence (WCC). From the theory of WCC has come the theory of Reduced Generalisation (Plaisted, 2001), which states that individuals with ASD are more able to identify the shapes within the figure as they have less ability to process the similarities between things than Nts, and therefore a superior ability to perceive differences. A further study (Rinehart et al. 2000) has suggested that whereas Nts perception of the global will interfere with their perception of the local, their perception of the local will not interfere with their perception of the global (i.e. the global takes precedence). Individuals with ASD do not have such a hierarchy and are therefore able to perceive the local as easily as the global. In another study (Mottronet al. 2006) it is suggested that individuals with ASD perceived the local more easily than Nts because they have difficulty in broadening their visual focus out from a detail. From this it is inferred that the difficulty does not lie in integrating local elements into a whole, but rather in broadening the attention to take in more elements. The theory of WCC also has implications on an individual's ability to make sense of written sentences. If words or indeed letters are read locally rather than as part of a whole then they will form incoherent lists rather than meaningful messages.

The incidence of autism amongst children is thought to be increasing globally. Before the late 1980s prevalence was thought to be only 4-5 in 10,000. A 2006 study of 57,000 children aged between 9 and 10 living in England estimated prevalence of ASD to be at 166 per 10,000 (Baird et al. 2006). Children with a current clinical diagnosis of ASD and those on the special educational needs register were screened. It showed that the prevalence of children already known to have ASD was 44 per 10,000 and there was therefore a significant increase suggesting that as many as 1% of children are effected by ASD in the U.K. Wing (2005) argues that the reason behind this increase is because of the growing understanding of ASD, the inclusion of Asperger's syndrome and the broadening of the criteria of the spectrum.

The British Psychological Society position paper (2006), offers the following key principles in addressing the needs of children, young people and their families affected by ASD. These have been informed by the United Nations Convention of the Rights of the Child (1989), the Every Child Matters initiative (DfES, 2003) and the National Service Framework for Children (DoH, 2005).

The British Psychological Society position paper (2006) offers key principles for Chartered Psychologists when addressing the needs of young people and families affected by ASD. These are:

- Listening to the child

The need to acknowledge the right of children to express their views freely on matters affecting them.

- Access

Wherever possible, appropriate services should be provided locally and be responsive to the needs of individual children and their families or carers.

- Working together

Planning, assessment and intervention require collaborative partnerships with parents and between professionals.

- Individual differences

It is important to acknowledge individual differences and levels of need. In particular, the strengths, interests and needs of each child should form the basis for practice.

- Inclusion There is a multi-agency responsibility to facilitate the inclusion of children and young people with ASD both academically and socially as far as is appropriate.

- Securing the health and well-being of children, young people and their families

It is important to locate responses within the framework of desired outcomes for children and families which are set out for all young people (including the prevention of harm) and based on all available evidence.

The paper goes on to detail the specific contributions that Chartered Psychologists can make when working amongst a multi-disciplinary team with children affected by ASD. These numerous contributions demonstrate the high level of responsibility and knowledge required of psychologists working in this field. As well as being to identify, assess and suggest interventions for ASD, the psychologist is required to be able to work as part of an inter agency team, and to be able to communicate with and work alongside other professionals as well as parents and carers. This broad range of skills and knowledge illustrates the need for an holistic approach when working in this area, and also the high level of professional demands placed on the practitioner.

During the development of Project Spectrum (detailed in Section2), the resources were not available to employ a psychologist as part of the project team. However the project was developed in close consultation with parents and carers and with members of the local autism support unit. The above guidelines are reflected in the approach taken during Project Spectrum, which was holistic and placed the child, their individual needs and their well being at the centre of the project. It also engaged collaboratively with the wider community involved with the child. Furthermore by locating the Project Spectrum environment in a mainstream school, the project offered an inclusive academic and social opportunity for the children.

2.2 Co morbid conditions

"If the largest percentage of cases (sic) of autism occur in those with compounding co-morbid (co-occurring) conditions, then the idea of 'pure' autism is actually referring to a rarity."

Donna Williams (date not given) – Fleas and autism

There are several co morbid conditions associated with autism (Zafeiriouet al. (2007). Some of these, such as Attention deficit Hyperactive disorder (Ad/Hd) and Dyslexia, are gaining more recognition in the public realm, and they are sometimes (mistakenly) referred to as being areas of the autistic spectrum. To avoid confusion it is helpful for the designer to understand such distinctions, and to be comfortable with the acronyms and terminology. During this research I have encountered children with different diagnoses including ASD, and also children who have exhibited ASD like behaviours yet had a different diagnosis. This 'rainbow' of conditions and the discussions surrounding them, makes design for this group particularly complex.

This research is focused particularly on the development of interactive digital tools for children on the autistic spectrum because the literature has identified them as having a particular need for social engagement and an affinity with computer controlled systems. This does not mean that the tools developed may not be engaging for NT children or for children with other special educational needs, but it does entail that the design is centred on the requirements of children diagnosed with an ASD. In addition this research was funded to develop interactive digital media for children on the autistic spectrum, and it was not therefore in the remit of the project to develop for other groups. However whilst carrying out the research, I found that a greater knowledge of co morbid conditions was necessary in order to more fully appreciate the children I encountered and the view points of the those who worked with them. There now follows an overview of the co morbid conditions experienced by individuals encountered over the research period.

<u>Attention deficit Hyperactivity disorder (AdHd)</u>

Because AdHd starts in childhood, it can only be diagnosed if symptoms are experienced before the age of seven (NAS 2006). These symptoms are described as inattention, impulsivity and hyperactivity. Children with AdHd do not necessarily experience the same difficulties with communication as those on the autistic spectrum, although they may have difficulty in some social activities as a result of not being able to settle to a particular task or activity. However the condition cannot be diagnosed if experienced solely as part of an autistic condition. The two are not mutually exclusive but the needs regarding the autistic condition should be met first.

The cause of AdHd is thought to be 'bioenvironmental', indicating that it has both a biological and environmental cause. Dyslexia is a condition which is recognised as a difficulty with reading and writing and is seen to co-occur with AdHd at a rate of 30%-50%.

Sensory Dysfunction

Sensory dysfunction indicates a difference in sensory processing (Rogers and Ozonoff, 2005). It is described as one or more of an individual's senses (smell, taste, vision, hearing, touch, vestibular (balance), proprioceptive (location of one's own body and limbs), and kinaesthetic) being subject to over (hyper) or under (hypo) arousal. This may manifest, for example, as an over preoccupation with a particular stimulus such as a light, or as distressed behaviour in the presence of a high or low pitch frequency sound. In both cases the source of the stimulus may go unnoticed by those with the individual. Rita Jordan (2004) gives the example of a young lady who would repeatedly become distressed when visiting a particular restaurant with her family. It was only after several visits that the family realised it was the position of her chair than was causing her alarm as it meant other people were constantly walking behind her. Moving her chair, so that her back was against the wall solved the problem. Descriptions of such symptoms are common amongst individuals on the autistic spectrum who are able to report on their experiences. It has been argued that it is these perceptual differences that lead to difficulties described in the triad of impairments. A recent study (Kernet et al. 2007) suggests that for children with ASD, sensory processing dysfunction is global and that this may in turn relate to the severity of autistic symptoms. It is also suggested that all the main senses (auditory, visual, touch and oral) can be affected and that a dysfunction in one sense is not independent of the others. Familiar autistic behaviours such as spinning and hand flapping as well as some self injurious behaviours are argued to occur as a result of the need for self stimulation, and removing the sensory feedback that the individual is seeking will stop the behaviour (Lovaas and Smith, 1989).

Movement difficulties

Clumsiness is often experienced by children with an ASD, (Attwood 1997) and some have ascribed this to dyspraxia. Dyspraxia is defined as a developmental disorder in gestural performance in children whose basic motor skills are intact (Dewey 1995). Other studies (Weimer at al. 2001) have suggested that this clumsiness is a result of difficulties with proprioreception and that in particular children with Asperger's syndrome compensate by becoming overly reliant on their visual input to keep their balance.

<u>Monotropism</u>

Murray et al. (2005) argue that a central feature of autism is monotropism or 'attention tunneling'. Their hypothesis states that the conscious individual has a limited amount of attention available at any one time, which is divided to a greater or lesser degree between various mental processes. Attention may be broadly distributed between the processes or it may be highly focussed in one area to the detriment of others, and this they argue is the case with ASD. Activities such as social interactions and language use demand a broad distribution of attention, which the child with an ASD experiences difficulty with.

This argument is put into the context of performing tasks. Each task presented to the individual makes demands on their attention. "A task is an enacted interest. In order to perform a task (as a task) any individual needs to:

- see the point of the task - understand the goal
- value the point of the task - be motivated by it
- see how to perform the task - understand precisely what task it is, what steps must be taken to carry it out
- know how to take the identified steps"

Each of these steps, Murray and Lesser argue, may be difficult for the monotropic child to achieve. If the child is motivated by the task then it may be that they engage with it exclusively. This is often reported as obsessive behaviour where attention locks onto a single task.

For the purposes of design, these can form useful guidelines when considering the development of experiences to engage the child on the autistic spectrum. They also raise the question of how to evaluate the appropriateness of that engagement. For example a typical autistic behaviour is spinning the body. This is an example of 'stimming' or self stimulatory behaviour (Exkorn, 2005), which a child uses for reassurance. However, this behaviour can also be described as monotropic as it isolates the individual into that one task. Such monotropic behaviors might provide a starting point for engaging design that takes the child's existing behaviour and builds on it to include new experiences, with the possibility of engaging with another person through the experience.

For Murray and Lesser the computer offers a method of joining 'attention tunnels' between individuals. They argue that the computer offers an "autism compatible environment" that is a haven in a world that has become less and less autism friendly. "Computers offer scope for play, exploration and creativity in a safe environment which need make no verbal demands". In addition computers can allow for communication without the need for body language and face to face interaction. They provide a systematised and rule based environment which the user can control through the interface. With an ever expanding network in the world wide web, they allow for a plethora of social communication that was previously impossible. It is this network facility that is one way of offering a link between the attention tunnels of multiple users.

Discussion

It is clear that autism is a complex and not yet fully understood condition. Being a spectrum disorder means that the community of individuals affected by autism will exhibit a wide variety of symptoms. Grandin (1995) says that some individuals can learn to mask their symptoms just as 'an actor might prepare for a performance' whilst others will be clearly distinguishable within a group of Nts. This coupled with the various associated co morbid conditions indicates that this is a population for whom innovative design may help to address a variety of emerging requirements. Designs should be tailorable, recognising that autism is a spectrum disorder, that it can be present amongst a range of co morbid conditions and that the needs of the child may change as they continue to use a particular design.

This research is not concerned with developing a 'therapy' or 'treatment' for autism, but rather considers how interactive technology may play a part in providing positive experiences for children with an ASD. As such for the designer working with these users, the concern is to have a preparatory knowledge of the symptoms experienced by the children rather than any knowledge of the underlying cause.

Whilst this research takes a user centred design approach coupled with action research, a preliminary review of existing literature about autism helped to form an initial understanding of the community for whom Project Spectrum would be created. The primary advantage of this was to provide the researcher with much of the language and critical thinking surrounding the subject, its history and current understanding, which helped him when approaching the community and potential users, to begin dialogues that would inform the development of Project Spectrum.

Whilst the literature review provided a theoretical understanding, it was found to be no substitute for working directly with the community. By working with users (and the wider stakeholder community), the researcher developed relationships that were not defined by ASD but rather by shared experiences. For this reason the research highlights a possible pitfall of approaching design projects for children on the autistic spectrum with only a theoretical understanding of autism based on the literature, and warns that this might result in unsuitable designs and artefacts.

The work of Murray and Lesser (2005) provides a useful starting point for the production of computer based interactive media for this group. Their theory of monotropism and the steps necessary to motivate and engage a child in a task and eventually 'join tunnels' provides a theoretical understanding which can form the basis of practical work. In addition their work specifically deals with the role of computers in promoting this engagement and for providing playful and exploratory experiences. This has informed the development of Project Spectrum, which has also sought to provide enjoyable, open ended experiences created in computer software and delivered through technology.

My observations of children with an ASD working with computers have shown that this can be a solitary experience for the child, who becomes locked into their interaction with the software, visually through the monitor and tactilely through the mouse and keyboard. Often the child will have a favourite piece of software, often a game although sometimes an application such as Powerpoint, which they will repeatedly return to and engage with in a repetitive manner, sometimes not to achieve the 'goal' of the game or application, but rather to achieve a goal which the child has set themselves. For example making a certain sound effect play or by holding down keys, watching a particular letter fill the screen and then deleting it again. This behaviour demonstrates how interacting with computers can become a monotropic experience for the child. Part of the remit for Project Spectrum was to harness the enthusiasm shown by many children for computer based experiences to create novel experiences that would address the social difficulties experienced through the triad of impairments. This would mean designing not only software solutions, but also the best way to deliver them so that the experience might be engaging and shared; and creating an environment in which this activity could best take place.

In particular Project Spectrum is concerned with the creation of an environment that is sympathetic to the sensory requirements of children on the autistic spectrum. This had to be achieved before the introduction of the interactive media. If the child is unhappy with, or distracted by, their environment then it is expected this will cause additional difficulties when they attempt to engage with activities within this environment. This was witnessed first hand in some of the early prototype demonstrations in the community, which had to be shown in whatever space was available.

For Project Spectrum I took a community centred approach to creating this environment (which is detailed in chapter 4), discussing its design and bringing users into the environment as it was created, to evaluate and inform its continued development. The literature on sensory dysfunction provided a background to this process, and enabled me to understand many of the common sensory issues faced by the children I would later work with during the research.

2.3 Interventions for autism

At present there is no known cure for autism. Much current scientific thinking suggests that there is a definite genetic link (Xiaoyue Zhao et al. 2007) to the condition and that specific genetic mutations may be identified which may be hereditary. However this strand of research is controversial within the autism community (Murray, 2006), many of whom do not view autism as a disability but as another expression of human diversity, that needs to be understood by society rather than removed from it.

There are many and varied interventions offered to children on the autistic spectrum and their parents. It should be noted that the huge range of the autistic spectrum combined with the variety of interventions available can be taken as indicating that no one intervention is suitable for every child on the spectrum. A discussion of the medications used with autism will not be included here as this is beyond the remit of the research.

ABA

Standard interventions such as Applied Behavioural Analysis (ABA), speech therapy and special education should be commenced as early as possible if they are to be effective. (Baron-Cohen, 2004) ABA relies on intensive, highly structured and repetitive sessions in which a child is rewarded for each correct response to a specific command (Bogdashina, 2005). The intervention normally takes place in pre-school years and parents share the delivery of the program. The intervention is intensive and one to one. The first stage is to reduce aggressive and/or self stimulating behaviour and to encourage imitation and play. Following this expressive language and interaction are introduced. Speech is taught through verbal imitation and receptive discrimination of pictures and objects. The third stage develops emotional expression and observational learning. Any challenging behaviour is dealt with through ignoring it and time-outs.

ABA is often referred to as the Lovass method after Dr Lovaas who claimed that 47% of children receiving intensive 40hr a week ABA "achieved normal educational and intellectual functioning and were successfully mainstreamed into standard classrooms"(Lovaas, 1987). A recent study (Reed et al. 2007) however contradicts

Lovaas' findings, stating that whilst children in the ABA program did make intellectual and educational gains, there was no evidence of recovery from autism. This echoed the earlier findings of Jordan and Jones (1999) who concluded that early intensive education involving the parent could produce significant positive results, but not recovery. They stressed the need to research why some children responded more to treatment that others. In addition a recent Australian study discussed the use of behavioural approaches in teaching children with autism how to play and interestingly concluded that “the most effective behavioural interventions have been those which have built on children's existing abilities or have relied on the motivating nature of the activities themselves rather than external rewards.”(Luckett, et al. 2007).

This underlies some criticism of the ABA approach as it relies on a reward system that may not be suitable for children with an ASD (Williams, 1996). Given the sensory hyper sensitivities of many individuals, a hug, tickle or even food as a sensory reward may be totally inappropriate and in fact have the opposite effect. Verbal rewards, facial expressions and other body language such as clapping may also be misunderstood. Similarly the reactions to challenging behaviour may result in pleasure for the child, leading to much confusion between the individuals.

A major concern within parts of the autism community is that the prevailing view of autism occurs from the standpoint that the Nt's method of communication is correct, whilst the individual with an ASD method of communication and experiencing is incorrect and should be modified to match that of the Nt. (Baggs, 2008) This is reflected in the concerns about the philosophy of ABA and that it lacks understanding of the autistic perspective.

This research takes the requirements of the children and their community as the starting point for designs, and goes on to embed them into original designs. The use of the resulting artefacts also centres around the community, an by employing a facilitator who is trained in working with individuals on the autistic spectrum, the work can be tailored toward the perspective of the children, taking their responses as the starting point for engagement.

<u>TEACCH</u>

One approach that may be regarded as stemming from ABA is the Treatment and Education of Autistic and related Communication handicapped Children (TEACCH). TEACCH (Van Bourgondien and Schopler, 1996) uses a structured approach to education with visual cues to prompt behaviour. The family of the individual is considered to have expert knowledge of that person and are key participants in the intervention. TEACCH recognises the individuality of each participant, and each one's unique skills play a part in developing a bespoke approach, alongside recognising where their ASD makes it difficult for them learn new skills. In this way strengths can be used to compensate for weaknesses.

Challenging behaviour is recognised as the result of an individual's inability to encounter their environment successfully. This should be addressed from the perspective of the individual and their ASD and then action should be taken to adapt the environment to make it understandable and suitable. The approach considers physical and material organisation, and timetables to create a very structured view of day to day activities. This systematised and visual approach is said to be less confusing and therefore reduce anxiety. This is combined with a predictable and planned visual schedule of activity which whilst not necessarily repetitive, means that there are no sudden changes for the individual to deal with. This embedding of a routine is argued to help with the education of the individual and to make approaching novel situations in the future more easy to cope with. Similar to the Lovaas method, TEACCH tailors communication tasks to the individual, starting with the evolution of a communication method, right through to the more social aspects of communication, and skills needed for specific tasks. Bespoke leisure tasks are also developed that centre on an individual's own interests, and social tasks can be evolved around these.

The influence of the TEACCH approach can be seen in many special education situations for children with ASD, even if it is not followed in all aspects. It is generally felt that most children with ASD benefit from a structured approach to their education and that they are visually motivated and therefore benefit from a visual approach to the organisation of their experiences at school.

Speech and Language

It is estimated that between a third and a half of individuals with an ASD do not use speech functionally (National Research Council 2001). This along with the rise in incidence of ASD has presented a significant challenge to those working in the field of speech and language. However children with autism do not necessarily need to learn how to speak a language, they need to learn how to use language to communicate. For example, many children with ASD will be echolalic, repeating back words or whole chunks of vocabulary that they have heard, but that are not socially appropriate to the moment and do not have meaning beyond that which the child may prescribe them. To meet this need, speech and language therapists must research and develop appropriate responses (Diehl, 2003). For many (Mirenda, 2003) this will include the use of augmentative and alternative communication (AAC) systems that employ signs, symbols and pictures such as PECS (picture exchange system). Additionally they may require the use of voice output communication aids that produce synthesised speech on the child's behalf. This leads into the area of facilitated communication where an individual without verbal skills might use an interface such as a keyboard to communicate with the help of a facilitator to overcome any disability in using the equipment. The success of this approach relies heavily on the sensitivity of the facilitator to the abilities and requirements of the individual as it will be a combined effort to bring about successful communication. Similarly Project Spectrum recognised the importance of the facilitator in tailoring and supervising sessions using interactive media to enhance engagement. Their role was to guide the child through the experience, identify their responses and plan further work both inside and outside of the environment. Having someone who could work on this more holistic level with the child was invaluable to its success.

<u>Intensive interaction</u>

Intensive interaction emerged from Harperbury Hospital School in the U.K. in the 1980s and was originally referred to as Augmented Mothering (Ephraim, 1986). It was developed as a teaching approach for children with complex learning difficulties, specifically ASD, to teach them pre speech communication skills. It was designed to help individuals share attention with another person and from there develop more complex and sustained communicative relationships. This would include activities such as eye contact and facial expressions, body contact and gestures and finally vocalisations. Sessions take place on a one to one basis and are spontaneous and bespoke. However they include common features: "the creation of mutually pleasurable interpersonal games and playful ritualised routines; the kind of facial, vocal and gaze behaviours which infants typically elicit; altered timing of behaviour with essential rhythms, repetitions and pauses; the imputing of intentionality; and responding contingently, following rather than leading "(Nind and Powell, 2000). These guidelines give a framework for the interaction sessions, though there are no predetermined outcomes. Sessions should be frequent and there should be an awareness of moving from basic acknowledgement of each other to more complex interactions and vocalisations, although any time scale for this will of course depend on the individual.

A similar approach was taken during the delivery of Project Spectrum, placing the child at the centre of the evaluation and allowing them to develop their engagement with the digital modules, the facilitator and the environment in their own time. Daily sessions were held at regular times. The outcomes of these sessions were not predetermined, but rather started from the child's requirements on that day and developed from there. Over time more complexity was introduced to the sessions at a rate dictated by the responses of the child, so the child's relationship with the Project would mature in a holistic manner.

Key to intensive interaction sessions is the imitation of the individual by the facilitator. Copying their behaviour "offers a gateway to a relationship" (Caldwell, 2006), as this attempts to use a language of communication that is dictated by and therefore understood by the individual. The facilitator moves into the communicative world of the individual, and whilst they may not initially understand it they will participate in it to create meaningful interactions. In ASD, typical behaviours such as spinning and flapping will be imitated in the hope that the individual will notice and recognise the behaviour as one of their own activities, and through this recognition acknowledge the other individual. Having established this link it is important for the facilitator not to simply fall into constant imitation of the child, but to gradually introduce change. When the child taps the wall once, the facilitator taps it twice for example. It is hypothesised that using gradual change starting from the individual's behaviour, new forms of communication can be evolved and a repertoire created that draws the child from their own inner world to the external world of the other, which they have difficulty engaging with.

For the delivery of Project Spectrum, a facilitator was employed who was experienced in working with children on the autistic spectrum and who was able to tailor the environment and the interactive modules to meet their requirements. In addition she worked with children throughout sessions before, during and after using the modules, to ensure that they had a consistent and enjoyable experience, and to work on developing their engagement skills through the use of the modules.

Son-Rise

In the U.S.A. a similar programme called Son-Rise has become popular. This is based on the work of Barry and Samahria Kaufman (1984) who developed the technique to meet the needs of their own son, Raun. This has met with remarkable success. Using a similar interactive approach, Son-Rise pays particular attention to creating a suitable environment in which interaction can take place. The programme trains parents in the approach and they lead the intervention from home, taking on some of the role of the therapist (Williams and Wishart, 2003). This is a child centred approach that teaches parents that their child is special and that their love and acceptance will enable them to follow the child and to learn from them. Like the approach of intensive interaction, Son-Rise teaches that copying the child may form a route into their world.

The Son-Rise playroom is designed to be a distraction free environment as this is thought to be the best space for the child to engage with other people. This is a sympathetic approach to the sensory processing difficulties inherent in ASD. Parents are encouraged to create such a space within their own houses. The room should take into consideration possible sensitivities to light sources including daylight, sounds and colours. It is also recommended to remove any electronic equipment such as televisions as they provide passive entertainment in which the child can become absorbed (NAS, 2007). Son-Rise also advocates a gluten and casein free diet, which is a dietary intervention suggested by various groups and practitioners (Jackson, 2003).

The Son-Rise program has attracted criticism, initially for offering a 'cure' to autism (Kaufman, 1984) and also for the costs involved to parents. The intrinsic role of the parents is problematic as it is impossible to monitor how much time they put into the program and how closely they adhere to the guidelines of the program (Williams, 2006). Additionally no formal objective evaluation of the program has taken place (Jordan and Powell, 1993) that would justify its use. Despite this it remains popular with many people.

Auditory Integration

To address the various auditory sensitivities experienced by many individuals on the autistic spectrum, a range of approaches have been developed, that are collectively referred to as Auditory Integration Therapy. These include the Tomatis method, the Listening Program, the Samonas method and Auditory Integration Training (AIT). AIT was developed by Dr Guy Berard in 1982, who argued that in spite of hearing ability, hyper or hypo sensitivity to particular sound frequencies would result in behavioural and learning difficulties (Berard, 1993). This work was popularised when a mother claimed that her daughter had been completely cured of autism by the method (Stehli, 1991). The method involves using headphones to listen to 10 hours of electronically modified music over 10 days, with two half hour sessions per day. The sound listened to is modified using filters to remove particular frequencies, and is modified to varying intensities to suit those with auditory sensitivities. The other approaches are similar and use varying mixtures of music, human voice and nature sounds delivered over headphones.

Snoezelen multi-sensory environments

When discussing the term ‘sensory environment’ over the course of this research with teachers, parents and carers working with children on the autistic spectrum, their most common understanding of this was that of the Snoezelen multi sensory environment. These originated in Holland through the work of Hulsegge and Verheul (1987), who created sensory environments that emphasised experiencing sensations rather than analysing the experience and in which there is an ‘empathic appeal to the senses’ (Hulsegge and Verheul 1987, p.11). These were for use with people experiencing profound mental and physical disability and designed to promote exploration and relaxation, hence the name Snoezelen coming from two Dutch words meaning to sniff and to doze. Interestingly Hulsegge and Verheul define this term as a process of enjoying an environment rather than the room itself (Fowler 2008 p.19). During the action research I have found schools generally consider a sensory room to be a specialised and isolated environment in which specific sensory work takes place. One of the outcomes of Project Spectrum was to begin a dialogue with schools suggesting that they start to consider their whole environment as a series of sensory environments, and that sensory work should be pervasive across the school.

Hulsegge and Verheul promoted an enabling approach (Hagar and Hutchinson, 1994, p9) aimed at empowering individuals visiting the environment by allowing them to play an active part in their sensory experience. They were invited to explore stimulating equipment and facilities, and to make their own choices about how to go about this. There was no preconception or guide on how to use the environment and this was emphasised in Hulsegge and Verheul's statement (1987) "We do not wish to give development and therapy a central focus within Snoezelen. It is fully open. We do not declare aims beforehand."

The Snoezelen environment originated as an activity tent which contained various sensory stimuli such as lighting and balloons (Hulsegge and Verheul 1987, p. 24). This tent was then recreated at the De Hartenberg Institute in Holland and developed in time into a large facility. Since then the term Snoezelen became increasingly associated with the room rather than the process, and companies emerged that commercialised this as a product made available to institutions who wanted a 'sensory environment'. Indeed one company has trademarked the name Snoezelen for their products. This increase in availability has led to many SEN schools purchasing variants of the sensory equipment and installing their own sensory rooms. However, despite their increase in popularity, valid empirical research into the use of Snoezelen rooms remains limited (Hogg et al, 2001) and it is therefore unclear about their suitability for all children. Whilst some positive responses such as a reduction in self harming and greater self awareness have been reported (Ashby et al. 1995), there have also been studies that have shown that reducing negative behaviour is no more successful in a multi sensory room than it is in a control environment (Chan et al. 2005). There has also been criticism that multi sensory environments segregate children with SEN (Whitaker 1992) from everyday experiences and that the activities they engage in whilst using the sensory facilities teach them nothing about the outside world.

It is clear that further research is warranted into the use of Snoezelen with SEN communities (Mount and Cavet,1995), and particularly when using them with children on the autistic spectrum. There is little rigorous research in this field and none that has focussed on developing engagement and interaction. A study by Fagny (2000) showed that the use of a Snoezelen environment by individuals on the autistic spectrum did help to alleviate anxiety, frustration and insecurity related behaviours for a short period of time. In another study McKee (2007) found that use of a Snoezelen room with three adult men with ASD resulted in "a slight tendency for clients to engage in more prosocial behaviors while in Snoezelen" but that "these findings do not support the contention that Snoezelen rooms are effective interventions for aggressive behavior in this client population".

Project Spectrum is being developed specifically for children on the autistic spectrum, and although it offers a different range of experiences to those offered in a typical Snoezelen environment, it does share the remit of engaging its user's senses, particularly using visual and audio stimuli. In contrast to the Snoezelen environment Project Spectrum has created a low arousal environment in which to deliver the interactive media.

Physical arousal has been proposed as an explanation of ASD (Hutt et al. 1964) and this theory implies that those on the spectrum will be more sensitive to sensory stimuli and slower to habituate to them. There is some evidence to suggest that children with ASD have different physiological responses than non ASD controls. For example it was found that five children with ASD had higher baseline heart rates (Goodwin et al. 2006) and reported unusually high or unusually low baseline skin conductance responses (Hoffman and Groden 2006). Whilst more research is needed in this area, it is notable that in Britain the government department for children schools and families (DCFS) released 'Autistic Spectrum Disorder Good Practice Guidance' (2002) in which they stressed the value of providing a low arousal environment for pupils to use to de-stress. Providing a safe place which they can use to 'chill out' away from others enables them to return to their peer group relaxed and continue with their learning. The following guidelines were issued by Warwickshire County Council for creating a low arousal environment:

•Auditory and visual distractions should be kept to a bare minimum. The room should not be next to areas of potentially high levels of sensory arousal. (-e.g. next to toilets, kitchens or in areas where there is a lot of 'traffic')
•The room needs to be enclosed but large enough for a 'workstation' (table) where one pupil and one adult can work comfortably on table top tasks. It is helpful if there is a corner to 'relax' (perhaps with a beanbag)
•The room should be free of additional fixtures and fittings that may become a distraction or have the potential to be used in an aggressive manner. It is important to consider the appropriateness of safety handles fitted to the door.
•There should be as few windows as possible to limit visual distraction but staff must be able to monitor the situation regularly through a window in the door. This window in the door should be at an appropriate height and position to allow staff to have clear 360 degree vision into the room.
•Lighting needs to be good and include a dimmer facility. No strip lighting should be used
•Suitable floor and wall coverings should be considered to reduce external noise and internal echo
•The room should have easy access to toilet facilities and an outside play area to minimise disruption to other pupils and staff
•There should be a facility for temperature control within the room.
•Consideration must be given to effective routine external surveillance as well as an acceptable system for emergency communication (e.g. a pager)

This research has revealed that meeting all of these criteria is not always possible, especially as space for such an environment is not always available in ideal locations. Also these particular guidelines are somewhat contradictory asking for easy access to toilets and playgrounds whilst also asking not to be near areas of traffic such as toilets. It is therefore the responsibility of those concerned with creating the low arousal space to negotiate with the school in finding the best space available. In the case of Project Spectrum, I discussed with the head teacher at the school where we were to install the environment, and together we negotiated a space that would meet most of our requirements whilst not disrupting the ongoing running of the school. Whilst the Project Spectrum environment did meet many of these criteria others were not met. For example the environment was located near the playground which meant that during break times there was a lot of noise directly outside the space. As PS was sometimes used during break times this was not ideal.

The value and need for dedicated resources was illustrated when visiting schools that provided low arousal rooms, although notably these were not as common as Snoezelen type environments. Speaking with staff at schools it was common for them to identify the need for a low arousal space and also for a space in which pupils could move around to work off excess energy in order to relax. Existing Snoezelen style rooms offered neither of these. Anecdotally over the course of this research several Snoezelen rooms have been seen that have been used very little by schools, and if it wasn't for the financial investment made, some schools would consider turning these into minimalist low arousal spaces instead. Growing populations at many SEN schools also means that they do not have the space to incorporate multiple rooms to meet the various sensory needs of their pupils. This is particularly pertinent when considering a growing population of children affected by ASD whose sensory requirements are often distinct from others at SEN and mainstream schools. A space in which tailorable activities could be presented would be more suitable.

Project Spectrum therefore sought to address the absence of a suitable environment by providing one based on the requirements of children with ASD. By creating a low arousal space within a school, pupils could have access to this environment either as a 'chill out' space or as a space in which they could continue their academic work if appropriate as it was equipped with tables and chairs, that were also organised to suit the needs of ASD pupils. Also available in the space were a set of digital modules that unlike traditional Snoezelen equipment, were invisible when they were not being used, 'hidden' as they were as software on the computer.

When needed the computer and other devices could be quickly turned on and the child could engage in the sensory activities offered. The shortcomings of this prototype system included not having access to any tactile materials as offered by Snoezelen rooms, and having some reliance on the facilitator to activate the computer and the desired modules. Given greater time and resources we would have added tactile stimuli, possibly as controllers for the visual digital media. For the purposes of this research it was necessary to work in a manner that provided vulnerable children with a safe, controlled and supervised experience.

Discussion

Whilst this research aims to enhance the experience of children with an ASD, it does not aim to develop any sort of 'therapy' or method of 'treating' autism. Our approach is to work with children and their community to discover how interactive digital media may be employed to give the children positive experiences which may augment the range of tools already being used.

It is clear that there are many different approaches to addressing autism in children, and that each of these invites a fair level of both criticism and support from members of the community. Fundamentally there appears to be a divide between those who view autism as an 'illness' and those who regard it as 'difference', leading to variety of goals in the broad selection of interventions. Clearly this is an emotive subject, and deciding which intervention is appropriate for an individual is a personal and medical decision beyond the scope of this research. This research has endeavored to compliment existing interventions and has drawn on some of the ideas expressed in them, such as the need for a structured timetable, the benefits of a low arousal environment and the ability of computer controlled activities to promote social engagement.

It is important to have some knowledge and understanding of the various interventions available, primarily so that when engaging with the community in a process of action research, one has the necessary background knowledge and language to enter into critical discussion with other practitioners and researchers. In addition it gives some understanding of the position many families and teachers find themselves in when they are presented with a range of possible courses of action and explanations in meeting the needs of their children. For example several of the schools who participated in informing this research had adopted aspects of the TEACCH program, which in turn had become part of their daily routine. As a designer visiting those schools it was useful to have some knowledge about the program in order to understand why certain classroom layouts had been created. In another school a program of AIT had been entered into and staff were interested in how this might relate to work being produced for their sensory environment. Again it was useful to have an understanding of staff expectations and the daily experiences of the pupils, and how new designs would fit into this existing structure.

The researcher seeking to develop new artefacts in this field, must consider their own position within the context of the many interventions available, and therefore how they are perceived by the community they are working with and for. After all, the action researcher joins with the community to address an identified 'problem'. In doing so there is the implicit suggestion that the broad range of interventions available are not sufficient and that new methods should be researched. The researcher may therefore experience resistance from members of the community who have adopted an intervention and perceive a new line of inquiry as in contradiction to that which they are involved in. Likewise they may have had a negative experience with a particular intervention and perceive new ideas within this previous context. For example during the research it became clear that several teachers provided with a sensory room facility had found it of little use with pupils on the autistic spectrum. This meant that they could identify a need for an alternative approach, but that they also had reservations about investment in new facilities given the failure of the previous ones. On another occasion, an educational psychologist was disparaging about designs for Project Spectrum as they did not fit into the approach adopted by her profession.

Having encountered practitioners and adopters of various interventions for autism over the course of this research, there is no doubt that being able to enter into discussion with them has broadened the perspective of this research. Whilst Project Spectrum has maintained its own aims and objectives, aspects of its delivery such as using blackout blinds and daylight bulbs, and designing an interactive balance board, have been informed by these dialogues, many of which have come from those members of the community directly involved in the project. It has also helped to position where the work exists within the autism community, and therefore how to best develop and present future work in this field.

2.4 Interactive media using computer vision

Introduction

The previous part of this chapter discussed the nature of autism and co occurring conditions. It examined the rising incidence of autistic spectrum disorders in the UK and the interventions available.

In the light of research showing that children with an ASD have a positive relationship with computers and computer controlled technology, this section reviews existing technology and technological art works. The work reviewed has inspired and informed the subsequent design of the prototype technologies detailed in later chapters. It is important for the designer to have a knowledge of previous and current work in this area in order that their work can incorporate this knowledge and can be considered as original.

This section examines the role of computer vision in creating an interactive experience for the audience. It details specific works and practitioners that have furthered the use of computer vision within the world of digital arts. It discusses how computer vision can be used to enhance engagement with the audience, how the artwork can become aware of its audience, and how the viewer is positioned within the artwork. This also involves discussion of the role of the environment in which engagement takes place and the interface, both of which can determine the presentation of the work and the method of engagement.

It goes on to examine how other media such as sound can be integrated into this relationship and the performative nature of the audience in computer vision based interactions. Within this is consideration of the playfulness of the interaction and how this might be harnessed to further engage young people.

Section 2.5 examines technological art and design projects that have been used specifically with children who have special requirements including ASD. It discusses how and why various projects have emerged, the research methods used to develop them and where they have been delivered. This review directly addresses one of the objectives of this research.

Computer Vision

“”Computer vision” refers to a broad class of algorithms that allow computers to make intelligent assertions about digital images and video. Historically, the creation of computer vision systems has been regarded as the exclusive domain of expert researchers and engineers in the fields of signal processing and artificial intelligence. … Recently, however, improvements in software development tools for student programmers and interactive-media artists … [has resulted in] a proliferation of new practitioners with an abundance of new application ideas, and the incorporation of computer vision techniques into the design vocabularies of novel artworks, games, home automation systems, and other areas.”

Golan Levin (2006)

This research began with an interest in how computer controlled media and environments could create engaging experiences in which the audience or user interacts directly with the work to develop reciprocal relationships which both empower and entertain. Specifically this would include experimental interfaces that would allow interaction without the use of a traditional keyboard or mouse and would instead employ devices such as motion sensors and microphones to promote a more ‘natural’ form of interaction between person and machine.

Artworks with awareness & the use of computer vision

Primarily, inspiration came from practitioners of digital media and media arts who had appropriated the tools emerging from digital technology to create new forms of artistic expression and user experience. Works such as ‘Text Rain’ (Utterback and Achituv, 1999) (See supporting AV material p.2) demonstrated how an audience could have an immersive and playful relationship with a digitally manufactured and delivered work, without the need for the additional apparatus needed when engaging with ‘virtual reality’, such as the head set and glove. This immediacy of experience appealed to an audience who were not motivated by technology for its own sake.

Furthermore the technology used in its production was flexible, portable and affordable.

The origins of this practice can be traced back to the work of artist Myron Krueger (See supporting AV material p.2-3). In the early 1970s Krueger coined the phrase 'artificial reality' to refer to the immersion of the human body in a responsive and interactive, computer mediated world. This event would be "so compelling that [it] would be accepted as real experience" (Krueger 1991). Krueger wanted this to occur without the encumberment of technological devices in order that the experience should be as natural as possible. However he did not seek to create work that reflected reality as attempted by practitioners working with Virtual Reality, but rather to create full body experiences that engaged the audience entirely.

He was one of the first practitioners to recognise the potential of using video cameras to achieve this, and one of his early works, 'Metaplay' (Krueger 1970) merged the live video image of the viewer onto graphics drawn by the artist, and the two were able to interact through this medium. "The environment established a real-time communication circuit between participants" (Hansen, 2006), in which the artist was able to draw on and around his audience, and could draw in response to their behaviour to give the audience the sense that they were controlling the interaction. This was a significant precursor to the computer controlled interactions demonstrated in his and fellow practitioners' future work. "By prototyping the experience rather than the technology ... Krueger was able to explore an aesthetic space of the interactive installation before the technology existed" (Cameron, 2006).

Krueger was also interested in creating responsive environments. By using a series of pressure pads on the floor he created a work called 'Maze' (1971) which tracked the position of the participant's feet and responded with both sound and visual elements projected onto a screen. He was one of the first artists to use a computer based system to translate the movement of an individual in a three dimensional gallery space across a horizontal space (the floor) into a vertical two dimensional projected representation (the screen) in real time, and to examine the relationship created between audience and avatar when one responds directly to the other. He was able to observe the inherent playfulness of the audience as they would explore the limitations of the system, discover the inherent rules and then attempt to circumvent them alongwith their self consciousness at being represented on the screen and taking on a performative role.

With 'Videoplace' (1975), Krueger demonstrated how, via a video camera, a computer could directly translate the movement of a participant into a response represented by computer graphics. The participant's image is gathered by the camera and from it a silhouette is created and projected onto a screen alongside computer generated graphics. Using computer processing, the system is able to determine the shape and location of the participant and compare this with the location of any other elements. A series of works based on this system were produced which allowed participants, via their silhouette, to manipulate and interact with virtual objects including the silhouettes of other users. This was the first interactive artwork to incorporate computer vision and over several iterations, Krueger demonstrated a wide range of methods that could be used to interact with the system. Interestingly this was all achieved before the ubiquity of the computer mouse as an interface. Through 'Videoplace' users could draw with both their fingers and bodies onto a virtual canvas. Over a networked system remote users could share the virtual space and manipulate objects and each other.

Interactivity - play, control and empowerment

'Text Rain' (Utterback and Achituv 1999) echoes Krueger's work using the interface of the silhouetted figure of its audience by capturing their image in real time using a digital video camera. In doing so the audience is placed directly into the artefact and becomes an essential part of the image. Through recognition of the self within the object, the audience is prompted to explore the work further, thus creating a 'real time' dialogue with the work through the movement of their body. This engagement is enhanced and contextualised by the descent of virtual letters on the projection screen which appear to settle on the figure of the audience, and which, through their movement, the audience can manipulate to form words and create new and temporary messages within the work. The audience is given a sense of agency, control and authorship whilst they engage with the work. There is an overriding playfulness about the experience, all reasons behind its success as an engaging and memorable artefact.

Another application of the silhouette can be found in Lozano-Hemmer's 'Body Movies' (2001) (See supporting AV material p.3) which uses the shadows of the audience as a tool for manipulating the virtual media. In using the shadow, the silhouette is explicit and unmediated by the computer, allowing a truly familiar visual point of interaction. By placing powerful light sources at ground level in public city spaces, this installation allows the audience to cast their own shadow at a large scale onto nearby buildings. The area where the shadow is cast then reveals images of citizens that have been photographed in the time leading up to the work being shown. Again performative, Lozano-Hemmer's work, which is identified as 'relational architecture', uses the human figure and its translation into two dimensional virtual space as the interface for the artwork. In another iteration, computer vision is employed to evaluate when an audience member's shadow matches in position and size one of the pre-rendered photographs, and in recognising this, changes the projected image to the next in the series. Lozano_Hemmer says of his work:

"Relational architecture can be defined as the technological actualisation of buildings and public spaces with alien memory. Relational architecture transforms the master narratives of a specific building by adding and subtracting audiovisual elements to affect it, effect it and re-contextualize it."

Lozano-Hemmer, R (1999)

Lozano-Hemmer's work suggests how the use of digital projection can alter our relationship with an environment. In Project Spectrum the highly visual digital modules rely on digital projection, and to a greater extent these give identity to the Sensory Classroom. For example the PECS figure created to symbolise the environment shows a child moving in front of the screen.

Lozano-Hemmer demonstrates a less explicit use of computer vision in his 2004 work "Standards and Double Standards" (See supporting AV material p.4), in which a

CCTV like system is used to track the movement of visitors to the gallery space. Rather than representing this motion directly onto a projection screen, it is translated into the response of a series of suspended belts, which rotate to face the visitors, suggesting invisible residents of the space turning their attention toward them. This installation is sculptural and its audience do not have to consciously engage with the computer controlled mechanism. In this sense we might refer to it as a 'reactive' piece of work which may then become interactive should the visitor start to explore their relationship with, and control over, the installation. This suggests principles for future design work in which children can engage with more discreet digital systems that may be represented sculpturally and in which the nature of the interaction is not immediately explicit.

Using vision to create sound

Between 1986 and 1990, David Rokeby developed his "Very Nervous System", (See supporting AV material p.4) which used computer vision to film and analyse the movements of the user and translated them into sound or music. Developed as a response against what the artist saw as the precise and logical nature of computers reflected in both their construction and their method of operating, Rokeby sought to create a system that was imprecise and fluid and whose interface existed in a volume of space that reflected a human scale rather than that of the machine. Interacting with the work could be very performative and suggested movements as appropriate methods of engagement. "The installation watches and sings; the person listens and dances". Beyond the performer and the system itself, there is no visual element to VNS. The relationship evolving between performer and machine is a subtle feedback loop between the fine and gross movements of the performer and the responses they receive as sound waves. The immediacy of this feedback leads Rokeby to dispute the use of the word 'dialogue' which suggests a call and response method of interaction. VNS illustrates something that is still observable in artistic computer vision endeavors, which is the difficulty in making precise interactions possible through a computer vision system without reducing the nature of the interaction to something simplistic and therefore possibly unengaging. This is particularly apparent when sound is involved as part of the computer's library of responses, as if this is returned in an unstructured manner the results can be difficult for an audience to interpret and will be eventually unsatisfying, dependent of course on the expectations of the audience. One might argue that a system such as VNS has to be learned just as any musical instrument in order to gain a sense of control and therefore 'reward', whereas an installation such as Text Rain being visual and using as it does the image of the participant's body, is far more immediately accessible if not holding the potential for sustained engagement.

The role of the sound artist compared to the visual artist presents different challenges when working toward an interactive media project, particularly when computer vision is the key interface employed. An interesting example of this is "Rapid Fire" (2000) by Andrea Polli (See supporting AV material p.5), who uses a head mounted camera to film her own eyeball, and by tracking its movement produces a range of sounds. The work is presented within the context of a performance. Rather like the VNS, there is a suggestion here toward interaction that is hard to control and imprecise, yet still engages with a debate about technology and art and the potentials within their combination.

More precise in its delivery of sound content is Golan Levin's 'Scrapple' (2005) (See supporting AV material p.5), which provides users with a loop of sound limited to four seconds within which they are able to construct a sequence of sounds. As with VNS the pallet of sounds is preordained within the system, and it is up to the user to discover and explore these. This is achieved by placing objects onto a three metre long table, along which a luminous scanner similar to what one would see in a photocopier runs and produces a sound whenever it discovers an object. The brevity of the loop means that users can quickly build up a familiar rhythmic pattern of sounds, which they are able to identify and manipulate through the visual and physical score they have created. Scrapple uses computer vision not to identify, analyse or represent any part of the human body, but rather to chart the changing position of objects within the system. In this respect one might see the design as reverting back to a more industrial use of the technology and hence the preciseness of the installation.

Levin is one of the leading exponents of computer vision within the world of media arts, and his work has encompassed both installation and performance. In Mesa di Voce (with Lieberman 2004) (See supporting AV material p.6) two performers produce virtual graphics onto a projection screen through their vocalisations. By using a computer vision system to track the position of his performers' heads across a stage, the graphics can appear to emanate from their mouths in an almost cartoonish manner, giving an immediate and entertaining visualisation of the sound. With this example, sound is the generating force and visual elements the product, demonstrating how the two can seamlessly flow into one another through a computer controlled system, depending on the intentions of the author.

Gaming and young people

The commercial potential for playfulness and gaming using computer vision to prompt interaction was demonstrated when Sony released their "EyeToy' in 2003 (See supporting AV material p.7) as an extension to their Playstation range of home entertainment systems. This was essentially a webcam which could be attached to the system and a range of games that takes advantage of being able to 'see' the user and respond to their movements. Some saw this as the beginning of a revolution in how games might be engaged with in the domestic setting, others viewed it more as a gimmick, and it is notable that over a relatively short period of time the EyeToy is now largely considered obsolete. However within that brief time the EyeToy has been tested as a potential therapy resource for use with children that can bring the benefits of play and embodied interaction to physical and cognitive exercises. Preliminary studies (Rand et al. 2004) showed that children enjoyed engaging with the interface of the EyeToy though they soon tired of the particular games (software) being used in the trials. It was concluded that there was unrealised potential in the system.

Whilst the EyeToy is no longer a popular game interface, the use of a computer controlled camera to embody the user within a two dimensional virtual environment and to perform motion tracking and analysis, remains a popular choice for many designers and artists; in particular those working with young people. One example of this is 'QuiQui's Giant bounce' (Hämäläinen, 2002) (See supporting AV material p.8). Developed as a student project, this is a game for children that uses a webcam and a microphone to allow players to control a cartoon dragon with their movement and vocalisations, and guide it past various obstacles. This work was featured as part of an exhibition of Finnish students at the Ars Electronica festival in 2006. It was designed to illustrate how children might interact with a computer in a way that challenged the image of computer use in a sedentary mode that takes time away from other more active pursuits and that can lead to obesity. The challenge of this computer game combines physicality with strategy and timing, demanding full body interaction from the player.

KidZone (igloo, 2006) (See supporting AV material p.9), is an interactive art installation for children that allows exploration of imagery, colour, shape and sound through movement. Designed to engage and entertain children rather than present them with the challenge of a specific rule based game, this consists of a series of short interactive scenarios which respond to the movement of visitors with a variety of audio visual media. KidZone was developed by a multidisciplinary team of artists including those working in the field of interactive media. Researched through workshops with a movement artist, each of the scenarios is designed to prompt different types of movement from children, both as individuals and in small groups. Computer vision was employed to document and analyse this movement then to produce a range of responses from the system. KidZone was premiered as part of the Lille 3000 exhibition in 2006.

Both QuiQui's Giant bounce and KidZone have enjoyed public success and have been featured in digital art exhibitions. They demonstrate the value of bespoke applications of camera controlled technology in contrast to the more commercial endeavors of the EyeToy. They illustrate the availability of the technology to practitioners today, the uses to which it is being put and more importantly the ease with which young people take to engaging with these new forms of delivery and interaction.

Whilst discussing gaming and young people, we should also consider the impact that the Nintendo Wii has had on the market. Whilst this does not currently employ computer vision, it has, through its use of motion sensors within the handheld controllers, provided new ways of engaging with digital media through gross body movements rather than just pressing keys or wiggling a joystick. The popularity of the Wii (Sanchanta, 2007) amongst consumers indicates that this more intuitive way of engaging with computer games may promote increased research and development into alternative interfaces for technology, as seen recently when Apple launched numerous unique game titles for their flagship Iphone with its multi touchscreen interface.

Discussion

The emergence of interactive technology has provided artists with a new and increasingly accessible toolset with which to create original experiences for audiences. They have responded by creating art objects that allow for and demand greater levels of participation and engagement, that have blurred the boundaries between audience and performer, and that have created more organic reciprocal relationships between human and machine. Whilst still generally regarded as outside of the mainstream art world, festivals such as Ars Electronica continue to showcase work that merges artistic concepts with emerging technology.

By using technology to record and analyse images and sound, audiences are now able to engage with artworks in ways that were previously impossible. Their image may now become part of the artwork; their movement around the gallery or the words they say during their visit may provide raw data that the artwork will interpret and respond to; and through computer networks this information could be shared with other artworks across the world. This information might provide a transient real time response from the system, or may be collected as part of a database of information. Art objects are emerging that require human input to provide the content that realises the artistic vision. This is a fundamental shift away from the passive artworks in mediums such as painting, sculpture or video, but which may still seeks to reflect these traditional forms.

It is this reciprocal interactivity between the person and the technology that excites my ideas for designing artefacts for children on the autistic spectrum. Having observed a common enthusiasm for technology, computers, video and video games amongst much of this community it seems appropriate to juxtapose this with the social difficulties they also face. Can offering a child the opportunity to interact and engage in an organic and bodily way with a computer controlled system begin to enhance the quality of their social interactions with other people? The technology offers the opportunity for the child to be represented visually within the work, either as their own recorded image or as an abstraction of themselves. It allows them to control this representation and to manipulate it, and it allows this experience to be predictable and repeatable. Specifically it allows the child an agency which they may not have in their everyday lives and through which over time they might develop increased confidence and skills which can be used in other aspects of their lives. What is more, they will be able to see this agency represented in a form familiar to many, that being within the 'magic rectangle' that modern children grow up with as arguably their primary source of entertainment. Using video and computer graphics makes the experience relevant to the child growing up in a digital age, and positions their experience within something that they view as valid, exciting and cool. This can only further their engagement with such a system, and hopefully therefore with other people and objects by extension.

Works such as Krueger's 'Metaplay' demonstrate how electronic visual media can provide an immersive and interactive interface that allows the audience to engage with the artist indirectly, by representing the expressions of both on a screen, located in an environment that supports this activity. For the child who has difficulty with social interaction and with face to face encounters, such a system might mediate the social experience to ease anxiety and to enhance understanding between the two agents. Being able to visually represent interactions with colour and shape may be a more appropriate and accessible means of communication, and could provide a starting point for other social activities. From this a facilitator might be able to work with a child to develop an increased theory of mind, as the child begins to recognise and engage with the actions of another person.

In addition, Krueger's work illustrated how the figure of the audience could be represented in real time on the screen to provide a recognisable image that can be manipulated by the individual. By positioning the child's image within the screen based media and by allowing this image to interact with other elements, it may be that a greater sense of the self and its relationship with and position in its environment can be developed. In particular, by using bodily movement to interact, children may be able to improve their gross and fine motor skills and their proprioceptive and vestibular senses.

The playfulness of works such as ‘Text Rain’ and ‘Body Movies’ shows how engaging experiences can be created that involve the audience interacting solely with technology. This is disguised within an interface that again uses the human form and specifically the silhouette of the individual, and the computer recognises this shape and translates it into the virtual experience. The quality of the interaction is relatively simple when compared to more complex computer software and video games, and yet the work has been found to be engaging and immersive for audiences.

Being able to generate and manipulate sound through body movements increases the range of activities available to children and may for some prove more motivating than generating visuals or visuals on their own. Incidentally I have observed that bringing sound to the experience does add an extra layer of engagement for most children, although the choice of sound is important and appropriateness for the individual should be tailorable. Having the computer generate only sounds in response to the children’s movement I have found to be less effective in sustaining engagement. However allowing them to vocally generate their own sounds and to see these represented visually as in Levin’s ‘Mesa di Voce’, has proved to be enjoyable and to encourage vocalisations from the children. Also manipulating their voices with digital effects such as delay has encouraged the children to experiment with the range of sounds they are capable of making. These prototypes were designed with the hope of encouraging vocalisations from the children with the view to increasing the social speech.

2.5 The use of interactive media with children with special needs

> “Computers can be an ideal environment for promoting communication, sociability, creativity, and playfulness for individuals even at the extreme end of the autistic spectrum”
>
> Murray and Lesser (1999)

The interactive installation

Sound=Space (Gehlhaar 1985) (See supporting AV material p.9), is an interactive installation that investigates how movement within a three dimensional space can be translated into sound and / or music. Sound=Space is a musical instrument, but unlike Rokeby's VNS, it employs a grid of ultra sound emitters and sensors to locate people within the space. This means that as well as providing a higher level of control to users it also allows more than one person to occupy the space at a time, and therefore participate in a collaborative experience. The ultra sound system can be calibrated to respond to both gross and fine motor activity and so is suitable for a wide range of movement applications. The sensors relay data back to one central computer, which in its latest form is a laptop, meaning that the installation is easily portable and can be configured to be used in a variety of settings.

Testing several iterations of Sound=Space, it became apparent to Gehlhaar that the work was particularly engaging for young people with special needs, including those with an ASD. He documented some of his observations and those of parents and carers who would observe their children playing within the space. One parent of a child with an ASD reported that, "After [an] initial reluctance to participate, my son, who is normally quite aloof from other children, tried to initiate contact with an unknown peer, saying he wanted to be friends. He was able to use the child's name without having been told it, i.e. picking it up for incidental conversation." Gehlhaar also recounts how one boy with severe autism did not participate with the rest of the group but would navigate through the space in an identical fashion over and over again, creating a repeated pattern of sounds through the ultra sound system. With the other young people in the group they then orchestrated a series of movements which created complimentary sounds to those being made by the one boy. In this way a group activity was created which included those who might not have otherwise been part of the activity. The boy was observed to recognise his part in the group activity and to enjoy the part he was playing within it.

Observations such as these demonstrate how a computer controlled system can provide a system of interaction and expression in which children with an ASD can feel comfortable. By creating a repeatable set of interactions and feedback children are able to familiarise themselves with the control they have over the system and use it as a form of expression. They also show how successful a multi modal approach can be to human computer interactions when working with children on the autistic spectrum. By associating movement with sound and encouraging children to explore with their bodies there may appear to be a residual effect of engagement which may not occur when controlling a computer with a keyboard and mouse and sitting down looking at a monitor. Installations such as Sound=Space equate the whole body with the interaction giving a sense of empowerment and engagement which is not available through standard HCI.

A similar appropriation of an interactive media installation can be seen with the adoption of the Iamascope (Fels and Mase, 1997) (See supporting AV material p.10) by Chadsgrove school for pupils with profound and multiple learning difficulties. The Iamascope is a large scale installation in which a video camera connected to a computer films the user and places their image within a kaleidoscopic image, in effect representing them as one of the pieces of glass one would find in a handheld kaleidoscope. Simultaneously the computer tracks the movement of the user to allow them to produce musical notes through motion. The kaleidoscope is projected onto a large screen so that there is no loss in scale between the participant and the projection. The result is a highly interactive work for one user at a time that provides immediate visual and sonic feedback, and that might be described as a musical instrument.

One iteration of it was installed at the now defunct Millennium Dome in London as part of its exhibition the Millennium Experience (2000). Located in the 'Play Zone', visitors to the work included a school party from Chadsgrove school. The teachers noted how much the children engaged with this particular work. When they later saw television footage of the Dome closing they contacted the curators and organised for the Iamascope to be installed as part of their new sensory facility at the school. It is now used on a daily basis by pupils at the school, and demonstrates the ability of technology based installations to fit into both the fabric and timetable of a school to offer original ways of addressing the needs of the pupils. It reinforces the argument for technology based interventions for children with special needs, where playfulness and enjoyment lead to fulfilling experiences.

Quantifying the experience

The Iamascope is described as exploring three main perspectives, these being 1.) the application of art and technology, 2.) intimacy with the interface and 3.) ubiquitous computing. Interestingly, regarding the first of these, the authors discuss how artworks produced with technology are often examined for their 'usefulness' and 'applicability' as they are understood as machines and subject to a critical line of enquiry that is not often present when discussing art objects. One might draw a parallel with the discussion of contemporary craft which although using tools and materials associated with the production of useful objects, can also be used to create objects for consideration as works of art. Fels and Mase (1998) describe how the technological art object becomes described as a "device". Such language is common when discussing media art, and one will see many references to 'systems', 'tools' and indeed 'technology', showing an emphasis on the materials used and the production method rather than on the object itself. Fels and Mase argue for an assessment criteria that states that "aesthetic experience is a useful 'function' of a 'device'" and that therefore the usefulness of the device can be measured in its achievement of the aesthetic experience. Those that enjoy interacting with the device are then described as 'users'. Reducing the experience to this language enables authors to comment on the Iamascope's own success as a useful object, however such an approach may not be appropriate for all art produced in this area, and may be argued to be an unnecessary step backwards when considering artwork produced with technology. However it remains an important debate still referenced when examining the wide range of works at exhibitions such as Ars Electronica.

Of more interest to practitioners seeking to engage children with special needs is Fels and Mase's (1998) reference to the 'intimacy' of the interface whose qualities are described as "providing feedback in real-time", "providing new functionality for the user", "supporting integration of the device into model of self" and "providing a learning path which supports development of highly skilled users to finely control the images allowing for personal expression". These descriptions help us to consider the qualities found in many interactive artworks and projects that have informed this research. The 'intimacy' of the experience may be understood to be fundamental to the process of engagement, and the interface is the first point of contact where this is achieved.

This leads into the idea of ‘ubiquitous computing’. This term, coined by Mark Weiser (1993), refers to the use of computing for everyday tasks where the computational process is hidden from the user, and the existence of the computer is irrelevant to the mind of the person interacting with it. The Iamascope seeks to achieve this through its novel interface design which absorbs the mind of the user, and there is no need or want for them to analyse the computational process taking place. In other words they engage with the surface and the experience, not with the engine behind it. An interesting distinction to note here is the difference between ubiquitous computing and virtual reality, as both are attempting to absorb the user in a computer controlled experience. However where virtual reality takes the user into the world of the computer, ubiquitous computing requires the computer to exist within the everyday ‘real’ world and to perform its functions transparently. For the purposes of this research it is important to consider the role of the computer within the experience. Firstly because the use of technology should not provide a barrier to those facilitating sessions, and secondly because the computer and its workings can be a big distraction for some children on the autistic spectrum. Just as with the Iamascope or Sound=Space, any computer based environment for children with an ASD should embed its technology sympathetically to create a focus on the interface and therefore more easily allow for the development of an ‘intimate’ relationship.

Site specific installations

Whereas the Iamascope was appropriated to become an integral part of the sensory facilities at Chadsgrove school, The World Their World (TWTW) (Drago et al. 2003) (See supporting AV material p.11) was designed specifically for the James Cook University Hospital in Middlesborough, as an installation in the Cleveland Assessment Unit. The unit is the Child Development Centre for children living in Middlesborough,Redcar and Cleveland. It provides assessment and therapy for children with significant special needs including autism, cerebral palsy and Downs syndrome, aged from birth to five years.

Having delivered a successful series of movement based workshops at the Hospital in 2000, Drago proposed to create a legacy work that would allow staff at the unit to continue with the movement work after she had finished her project. It was decided that this would take the form of a sensory installation within their existing sound and light facility, which would encourage movement and interactivity. An artistic team was created that included dance, music and multimedia practitioners. Furthermore a theme was decided upon, that being the voyages of James Cook who was born near to the hospital site, and around whom a series of artworks had been created at the hospital as part of the larger 'Healing Arts Project'. The work was designed to encourage 'intentional movement' from the children, and to help with their understanding of cause and effect. Furthermore it aimed to help with parent-child bonding within the unit, and aid staff in their assessment of the children.

Continuing with the workshop format, TWTW was iteratively designed over several months and included interviews and observations with all key stake holders. The artists worked with two groups of children to test and observe their engagement with the various prototypes that would eventually make up the final installation. Thematically these prototypes addressed three aspects of the James Cook story these being, Natural Worlds, Natural Environment and Navigation. Conceptually the artists worked to create a strong narrative to the work that would take the children on a series of journeys through the various stages of the installation, and would make the work more accessible. The journeys were created by compositing the children onto various video backgrounds that would allow them to experience different scenarios such as a flowing river, huge glaciers or the Australian outback. Seeing themselves within the image, they would appear to travel through each scene before arriving at an 'activity'. Each journey contained three 'activities' which would require different types of movement and provide various forms of audio visual feedback. These were more interactive than the traveling scenes. An additional standalone piece was also created for the installation. Named 'The Wiggly Worm', it consisted of a coloured and flexible line that followed the facilitators control across the screen. Using high contrast and vivid colours, staff were able to use this to assess the visual tracking ability of a child as their eyes followed the shape across the screen. To augment this, the worm could also be made to flash and make sounds to draw a child's attention to it. This was a particularly popular application with the staff and would later be reworked as part of Closer! (Drago et al. 2005), a sensory movement installation for children with autism. Because of the common areas of interest between Closer! and Project Spectrum, I was brought in as a co-designer on the project and in particular to apply some of the knowledge that had been gained developing PS in respect of developing technology for children on the autistic spectrum. My involvement in this project gave me access to the individuals involved in developing TWTW and therefore to discuss their experiences and findings in contrast to my own. Of particular use was their experience in developing interfaces that were quick and easy for members of staff at the hospital to use. Their method was reproduced and developed in both Closer! and PS and is discussed in Part 2 of this research.

TWTW employs computer vision through an affordable system of camera and computer to monitor, analyze and represent the movement of the children in the space. Using a data projector and speakers the children receive audio visual feedback from their movement. Much of the installation uses a compositing technique which removes the background of the unit and replaces it with selected videos, causing the child to appear in these new scenarios. This is achieved by careful control of the lighting in the unit. Unlike other such work, TWTW moves between a range of journeys and activities and allows a facilitator to control these events.

Just as with the other facilities in the light room, TWTW was designed to be used with a staff member as facilitator. The facilitator was responsible for controlling the installation through a computer interface and choosing which journey and activities were suitable for the child. The installation relied on easy to use technology, and was useful as it allowed staff to quickly familiarise themselves with it and to operate it in the absence of the artists. The user interface designed for the staff was very simple and employed large clear buttons and text with a minimal amount of control settings. Furthermore it could all be operated using a wireless mouse with no need for a keyboard, so the facilitator could be in the space with the child and operate the computer from a distance. This model of technology would inform the development of the system used in Project Spectrum and this is discussed in more detail in Chapter 3.

The children at the unit required a strong sense of routine in their daily activities. To introduce them to the new installation, familiar activities such as singing were conducted in the new space, so that they could familiarise themselves with the new look of the space. After this the equipment was turned on and children were slowly introduced to the new installation. The installation has now been running for four years and continues to be a success. Some of the technology has been updated and they have also received a copy of the new Closer! software (a sensory movement installation for children on the autistic spectrum) in return for assisting with its development. It was notable in the evaluation of TWTW how well staff had taken to the use of interactive media both as a tool for themselves and as an experience for the children. The technology had not been a barrier to access and they had evolved their own strategy of use which had emerged over time and familiarity with the installation.

<u>MEDIATE and issues of portability</u>

A notable discussion that occurred during the development of this research, and that took place not only amongst the development team, but also between myself and members of the wider community, was whether to present the digital modules in a bespoke, static environment or whether to create a portable design that could be presented in various spaces. The obvious benefits of the static environment would be that we would have more control over the delivery of the modules, and particularly over the sensory aspects of the environment in which they would be delivered. The technology would be always in place when needed, and children's sessions could be timetabled in the room. Taking a portable installation out into the community would enable us to test with more children in various locations, and would not require us to have a room as a permanent resource.

Following the reviews and subsequent discussions with fellow practitioners (see chapter 4 on gathering user requirements), it was decided that in the first instance we would create a static environment which children would visit. This was the ideal model, offering us far greater control over the sensory aspects of the environment and the structuring of sessions. This was later followed by the development of a portable installation which sought to offer the digital modules without the support of the PS environment. This allowed us to test the modules with a wider cohort of children.

Whilst works such as Sound=Space were portable applications that enhanced the environment they were installed in, MEDIATE (Creed et al. 2005), (Gumtau et al. 2005) (See supporting AV material p.13 -14) sought to create a truly portable self contained environment that would replicate an experience wherever it was set up. An acronym for "Multi sensory Environment Design for an Interface between Autistic and Typical Expressiveness", MEDIATE was a collaborative project to design and create "a space for creative expression and exploration via three sensory interfaces: visual, aural and tactile." It was designed for children aged between five and ten years with an autistic spectrum disorder and aimed to promote creativity in this group by allowing them to control and manipulate a multi-sensory experience.

The work took the form of an environmental installation which covered 56.25 square metres which contained a range of digitally controlled sensory feedback devices that responded to the activity of the child within the space. Controlled by computers, the digital aspects of the environment were designed to be intelligent in order that they should learn from the activity of the child and produce appropriate responses specifically to that child.

Whilst the project's home and final delivery was in Portsmouth UK, MEDIATE brought together an international team of experts in the fields of environment design, artefact design and manufacturing, software design and autism. Specifically these were

- Centre for New Media Research, University of Portsmouth, the central team for the project's management and realisation, and responsible for the overall design as well as specific aspects of environment and software design
- Faculteit Kunst, Media & Technologie, Hoogeschool voor de Kunsten Utrecht, Netherlands, responsible for sound design and implementation and for pattern recognition software
- Institut Universitari de l'Audiovisual, Universitat Pompeu Fabra, Barcelona, Spain, responsible for visual aspects of the environment and developing an infra red tracking system

- Social Genetic & development Psychiatry Centre, Institute of Psychiatry, Kings College, London, UK, responsible for informing the team on the user group, liasing with the autism community and evaluating the use of the environment.
- Show Connections Ltd, UK, who realised the designs for, and constructed, the environment, performed product research and created new parts when none were available.

Whilst the MEDIATE project shared several of the goals of this research, regarding the use of technology to engage those with an ASD, it is clear that the resources available to the MEDIATE project were far greater. Within the practical aspect of this research, many of the responsibilities detailed above would be the responsibility of a single designer who, with the support from the rest of the research team, would also be responsible for construction and installation of the work and data gathering for the evaluation. What MEDIATE provides the designer with, is an invaluable resource of experience to refer to when developing smaller scale work with similar aims. Although somewhat daunting in its size, MEDIATE provides a range of knowledge offshoots with which new work can be informed.

MEDIATE employs several methods for engaging the senses of its users. These combine visual, audio, vocal and tactile aspects. Specifically these are represented as:

- Two back projection screens showing abstract representations of the user's figure that mirror and respond to the user's movement and activity.
- A pressure sensitive floor that responds to the footsteps of the user by creating sound and also provides approximate information on the location of the user in the space.
- The 'Tune Fork' - a tactile device presenting many textures for the user to engage with and which returns information about this engagement to the computer controlled system in order to stimulate an audible response from the system.
- The 'Impression Wall' provides a series of vibrating surfaces that respond to the touch and pressure of the user

- Using microphones to make the environment sensitive and responsive to the vocalisations of users.
- Pattern recognition software 'signature', that detects if a child is showing repetitive behaviour and adapts the response of the environment accordingly.

The computer vision system employed within the Mediate environment demonstrated a high level of complexity. It was necessary to get highly accurate analysis of a child's movements within the space, without having to use any physical devices held by or attached to the clothes of the child. Such equipment would be inappropriate for the user group, would be likely to become damaged and might cause distress. Instead a system of infra red lights and cameras was installed. This was complimented by blacking out the space to prevent contamination from other light sources, and to maintain a high contrast in the images shown on the back projection screens. The infra red cameras are superior in tracking the movement of an individual within a suitably lit space. Infra red cameras were also positioned next to the projectors to monitor the back projection screens. This allowed the system to know when someone made contact with the screen by observing their shadow, and thus allowed the screens to become 'touch sensitive', and to respond to tactile interactions. The functionality of the space is therefore enhanced over a basic tracking system, although it also limits the lighting available within the space and does not allow for a direct mirror image of the child to be shown as this cannot be captured by the infra red cameras. While the back projection screens are highly illuminated, MEDIATE should be considered a 'dark' or 'black' environment, and this may be a barrier to access for some children should they find it disorientating or scary.

An interesting part of the project was the development of pattern recognition software 'Signature Analyzer', which allowed the computer system to record and analyse the behaviour of the child and, by passing information to the 'Decision Maker', for the environment to respond accordingly. This was designed firstly to engage the child, to prevent hypo or hyper stimulation, and to address the likelihood of rigid or repetitive behaviour. The system could therefore encourage a child to engage with it by responding to their presence, even if they were inactive ('tease');

reduce stimulation if the child's behaviour became excessively repetitive ('regulate'); or draw their attention to a different activity ('tease 2'). It could also detect when some creative engagement was taking place and encourage this activity. Creative interactions are described by the system as 'sustained activity that is non-repetitive'.

The development of an intelligent computer mediated environment can be traced back to Kreuger's 'Metaplay', but now the human element has been completely replaced by the machine. It references the use of ubiquitous computing to create 'smart rooms' in both commercial and domestic settings that support human activity and respond uniquely and appropriately to each user by recognising difference. However it is still debatable that for a child centred installation there should be a human element that controls the activity even if this is mediated through a computer controlled system, in essence making the environment the interface for communication. Reliance on the "signature' software, whilst a unique strength of MEDIATE, may also be seen as a misappropriation of technology as it removes the human interaction with which so many children with an ASD have difficulty. Alongside this, the 'signature' software can only track one user at a time, meaning that a child must enter the space alone in order to benefit from it. Dispensing with this aspect, would allow more than one person to enter the space and engage with the variety of sensory experiences together. This would be in keeping with the use of a traditional sensory environment, with the benefit that a third party would be able to control the environment remotely and interact through it, forming new modes of communication.

Where MEDIATE makes significant progress is in the range of computer manipulated experiences it offers, to provide cross sensory stimulation. By combining the tactile with audio visual, it moves toward a poly sensory experience. Avoiding the need for wearable apparatus and allowing for full body movement and exploration of the space gives a freedom to the MEDIATE experience that should encourage playfulness and therefore engagement. It is simple for participants to move between the different activities and to negotiate their own use of the space.

Robotics

The work of Robins et al. (2004, 2005, 2009) throughout the ongoing Aurora project, represents significant research into the role that robots may play in promoting the engagement of children on the autistic spectrum. Their project is located in the fields of assistive technology and human robot interaction (HRI) and is an investigation into how robots may be used as therapeutic or educational 'toys' specifically by children with autism (Robins et al. 2009). In particular they examine the potential benefits of interacting with robots compared to interacting with other people. For example, they have found that for some children the robots have encouraged the development of basic imitation and turn taking skills and for others the robots encourage tactile and playful exploration (Robins et al. 2005). Whereas children with an ASD may remain aloof and isolated with humans (Hobson, 2002), they may try to engage with the robots. In one particular study, a 'theatrical robot' was employed. A mime artist, who dressed and moved as a robot, was introduced to children with ASD. The children engaged through gaze and tactility. When the same man was presented to the children in ordinary costume and out of character, they engaged significantly less with him (Robins, Dautenhahn and Dubowski, 2004).

The Aurora project suggests that children with ASD may benefit from the use of a robot or 'theatrical robot' as the subject of 'attention' and 'joint attention' (Robins et al. 2004). Joint attention is described by Eilan et al. (2005p.5) as an event in which two or more subjects jointly attend to the same object, in which the following four claims are true:

1.) There is an object that each subject is attending to, where this implies (i) a causal connection between the object and each subject, and (ii) awareness of the object by each subject.

2.) There is a causal connection of some kind between the two subjects' acts of attending to the object.

3.) The two subjects' experiences exploit their understanding of the concept of attention.

4.) Each subject is aware, in some sense, of the object as an object that is present to both subjects.

This implies a ‘meeting of minds’, eg through attending to the same object. Research indicates that young people affected by autism have difficulty initiating such joint attention activities (Munday and Crowson, 1997; Leekman 2003).

The Aurora project uses robots to provide simple, safe and predictable interactions in which complexity can be tailored to the child. This simplicity of interaction may encourage the use of social interaction skills from the child and support the use of the robot as a point of shared attention between the child and an adult.

In general the work carried out during the Aurora Project is relevant to this research because both are aimed at a creating joint attention activities and employ computer technology to promote positive experiences. More specifically, Project Spectrum (detailed in Part 2) was designed to develop technology that supported the development of engagement between the child and an adult (the facilitator) and not solely between the child and the technology. This is an outcome that the Aurora project shares as it examines how “human contact (the experimenter) provides meaning and significance to otherwise mechanical interactions (the robot)” (Robins et al. 2004).

Another project that is researching the use of robots to interact with children with ASD is “Keepon”, which is a small, creature-like robot, designed to interact non verbally with children (Kozima et al. 2009). Using simple movements, “Keepon” seeks to express attention and emotion, and engage those interacting with it. It was observed during testing of ‘Keepon’ with the target audience that the robot would function as a ‘pivot’ in a triadic relationship between the child and caregivers, performing the same function as described in the Aurora project. The ‘Keepon’ researchers suggest that children with ASD do have the motivation to share mental states with others, and that this is brought out and demonstrated through their interactions with the robot. They argue that the ‘Keepon’ robot is “only capable of expressing attention and emotion” and that “this simplicity and comprehensibility might open a *bypass channel* through which children can directly perceive Keepon’s attention, emotions and therefore “mind” without being overwhelmed perceptually.” Whilst this research is not concerned with the development of robots, it does focus on the creation of visual stimuli for children, and often involves the human form. In several of the Project Spectrum modules, the child's own image is used as the basis of interactive visual media. The emphasis on simplicity found in the two robotics projects is echoed in the visual media created for Project Spectrum, which have also been designed to be tailorable in their level of complexity so as not to overwhelm the children with stimuli.

Inclusion through technology

Murray and Lesser (2005) argue that computers can be a useful tool when promoting the inclusion of young people on the autistic spectrum. They have found that 'autistic children may socialise more effectively in the structured environment of a computer' and that empathy between individuals can emerge through computer mediated interactions. They see the potential of the computer to 'level the playing field' between children with an ASD and neurotypical (NT) children as it provides a means of communication that is suitable to both. Using a keyboard to communicate rather than speech and not having eye to eye contact are factors that can be seen to benefit the communication style of the child with an ASD. In virtual environments children are often able to more easily engage in role playing activity which may improve their pragmatic thinking toward real world tasks.

Aesthetic Resonance

'Aesthetic resonation' was used by Ellis (1997) to describe when a person achieves control over his expression after a period of intense exploration. In particular it refers to moments of enjoyment and creativity experienced by individuals with profound and multiple learning difficulties when they achieve control over technology that allows them to express themselves in new ways.

Petersson (2006) describes 'the sense of flow that happens when there is a balance between stress and boredom' as she discusses the achievement of this resonance when individuals engage in activities involving interactive media. She explains that an activity should target the edge of a person's skills and stretch them a little beyond their limits. Aesthetic resonance is the moment of this balance, when an individual is engaging with a task at a level where they are being challenged and receiving reciprocal reward for completing the challenge. In the work of Brooks and

Hasselblad (2002)(See supporting AV material p.12), the resonance takes place between the individual and the technology. The gesture of the individual is interpreted by the technology and a response is returned immediately. This response takes the form of multimedia, feeding back sensory stimuli such as images and sounds. By giving the individual control to generate responses from the technology, the experience is seen as empowering and enjoyable.

Discussion

This review has shown how work such as Gehlhaar's Sound=Space and Mase's Iamascope, whilst not originally designed for children with additional needs, have nonetheless championed themselves through their design and interactivity with this group of users and their potential has been recognised by communities with little experience in interactive technology. This has been reflected in my own experience of bringing prototypes to the community and finding them readily used and enjoyed by the children and receiving feedback on how the work might be developed from their carers. What this highlights is that the community themselves are selecting interactive digital media as a means of engaging children, and discovering applications of existing interactive technology and art for themselves. This has been driven by the children's responses to the technology as the primary source of research. What is also interesting in these cases is the potential for cross disciplinary research to begin with artists discovering new outlets for their work and for carers to consider new ways of approaching the requirements of children. As this relationship develops so does the potential for the inclusion of new technology in the sites used by the children, as seen in the adoption of the Iamascope by Chadsgrove school.

Both of these works illustrate novel forms of interfaces for children to engage with the technology. Unlike more traditional mouse driven software the child can engage by simply moving into the 'reactive' space monitored by the system and it will in turn start to respond. The rules to this engagement are implicit in the design of the technology, and a child can be left to explore the limitations and to discover 'what works'. For example if they step out of view of the camera or ultrasound beams, the respective systems will stop responding. For this reason there is less reason for adult intervention and instruction on how to use the system as the child may discover the space for themselves and develop their own understanding of what is happening, why it is happening and how they can have agency over it. There is no right or wrong way to engage with these systems and their use remains both playful and optional. Children are given the opportunity to author the sensory audio visual experience that is reciprocated through their engagement and in this way achieve the 'aesthetic resonance' described by Ellis.

Harnessing this potential, works such as TWTW and Mediate begin to explore specific applications of digital media toward children and carers with specific requirements. In these cases the shift towards designing for a particular audience has allowed the final users more input into the design of the artefact, particularly at the early stages. This has placed a greater responsibility on the designer to meet and acknowledge these rather than creating work purely for their own interest. We might identify this as a movement from artistic vision toward design for requirements, and yet what makes these works unique is the artistic interpretation of the requirements by the designers into the final artefact.

These works also begin to ask questions of how examples of interactive technology that already exist in the world can be appropriated for the use of children with special and additional needs, and it is this question that this research explores with specific reference to autism. They are therefore significant precursors to Project Spectrum, which has attempted to delineate and contextualise the knowledge reified in these artefacts and in turn present some of this explicitly within new artefacts. For example the iterative approach to designing with a contained community at the Child Development Centre demonstrated how a close working relationship could be developed between artists and carers to produce bespoke designs that gave increased ownership to the final users. MEDIATE demonstrated how a variety of more complex sensory experiences could be combined into a single environment and also some of the difficulties in producing and maintaining a large scale artefact over time.

Children and technology

This research focusses on the design of interactive media for children, and it is important to consider this in the context of the experience of young people in the UK today. As digital tools become increasingly ubiquitous in their everyday experience, a new generation of technology users have emerged who have been labelled 'digital natives' (Prensky, 2001), a term which describes young people who grew up in the 1990's onwards, during "the arrival and rapid dissemination of digital technology during the last decades of the 20th century". Prensky argues that these people are 'radically different from previous generations as they are able to communicate 'natively' with digital tools. Those born before this generation he describes as 'digital immigrants' who have to learn the new language in order to use the tools. He argues that the digital natives 'think and process information fundamentally differently from their predecessors" and that their way of engaging with technology has led to them having different brain structures. For Prensky this dichotomy creates a tension in schools and education when older generations of digital immigrants are attempting to teach the younger digital natives using the very tools to which the natives are allegedly more adapted.

The views of Prensky are not however held by all, and a study completed by University College London (2008) on behalf of the British Library, identified trends throughout all generations in the way they used technology and specifically the internet as a research tool. This study named those born after 1993 as the "Google generation", but indicated that the manner in which they used internet tools were not unlike that of other generations. The report argued that a culture of skimming for information was emerging as a result of using the internet rather than traditional libraries and that the education of young people was suffering as a result of this.

Whether or not the relationship of young people to technology in the late 20th and early 21st centuries is distinct from previous generations, it is still true to say that in the developed world at least, it has had a significant impact on their educational and leisure experiences. A study by the Markle Foundation (Wartella et al. 2002), argues that more young people are adopting new technologies as a means of communication and asks what impact this will have on their social and communication skills. A report by the Kaiser Foundation (2005), found that young people in the USA are immersed in media and that playing games is the most common way for them to experience computers. The culture of gaming is indeed prevalent both on the home PC and dedicated consoles, and the UK games industry experienced its best ever quarter in 2008 despite recession in many other industries at this time (The Guardian, 2008). New devices such as the Nintendo Wii, Sony EyeToy, Microsoft Natal and Apple Iphone continue to offer more original, immediate and immersive ways for people to engage with computer games. When also taking into account existing media such as television and radio, which are also part of the 'digital revolution', alongside the computer used in schools, homes and the work place, we can consider that the experience of most people as becoming saturated with digital technology.

Whilst children are growing up in a 'digital age', they have a relatively small role in informing the design of the digital artefacts they encounter. Many of the devices and softwares that they use are identical or modified versions of those designed for adults. For example traditional interfaces for computers such as the mouse and keyboard were designed to suit to needs of office secretaries, mimicking the typewriter. These are not necessarily the best designs for interacting with computers unless your sole purpose is word processing and yet these are what people use when surfing the web or playing PC based games.

Conclusion

This chapter has provided the first part of the literature and state of the art review that has informed this research. It has discussed the history of autism, its diagnosis, the symptoms that are ascribed to it and several of the co-morbid conditions associated with it. The chapter then went on to discuss existing interventions available to children with autism, and their influence on this research.

Following this there was a state of the art review of interactive technology, particularly of technology that uses computer vision to engage its audience through their own image and their movements around a space. This continued into a discussion of projects that have used such technology to engage children with special and additional needs, and to consider the possible merits of using such systems with children on the autistic spectrum as means of promoting their engagement.

The reviews have revealed the rationale and context for this research, and shown that developing interactive technology for children with an ASD would be a valuable addition to work in this field. The following chapter concludes the literature review by discussing the design practice that has informed this research.

Chapter 3 - Literature review part 2: Design methods

Introduction

The previous chapter contained the first part of the literature and state of the art review. It discussed autism, its co-morbid conditions and existing interventions for children on the autistic spectrum, reviewed interactive technology, and in particular technology that uses computer vision to engage audiences by responding to their image and their movement around a space. This chapter concludes the literature review by discussing the design methods and theories that have been used in order to realise the artefacts and design models produced as a result of this research. This is the final chapter of Part 1.

It begins by defining and discussing user centred design (UCD) and the benefit of this approach to design work in this field. This includes contrasting UCD with activity centred design (ACD) and examining how both of these have helped in the development of the artefacts. This is followed by a discussion of educational ergonomics and in particular the development of the Hexagon-Spindle Model, which assists in the contextualisation and visualisation of how UCD will be experienced within learning environments.

This chapter then discusses the practice of action research. This includes consideration of reflective practice and how this has helped to shape the artefacts produced during Project Spectrum and disseminate and build on the knowledge derived from the research. Finally the chapter outlines the history of reflective practice and how it has been applied in this case. This is discussed in detail in Chapter 4.

3.1 User centred design

"The best designed products and services result from understanding the needs of the people who will use them. User-centred designers engage actively with end-users to gather insights that drive design from the earliest stages of product and service development, right through the design process."

Black, A. (2007)

Definition

User-centred design (UCD) is a term used to describe both philosophies and methods concerning design processes in which the end-user has influence over the design of an artefact. The level and manner of user influence will vary across UCD projects. Whilst this allows for a broad range of UCD practice, UCD is defined in international standard ISO 13407 : Human - centred design processes for interactive systems (illustrated below) (ISO, 1999). This does not propose specific methods for UCD but does define a general process for including human-centred activities throughout the development life-cycle of a design project.

Figure 3.1 - User Centred Design ISO (Usability Professionals Association, 2008)

In this model, once the need to use a human centred design process has been identified, four activities form the main cycle of work:

1. <u>Specify the context of use</u>

   Identify the people who will use the product, what they will use it for, and under what conditions they will use it.

2. <u>Specify requirements</u>

   Identify any business requirements or user goals that must be met for the product to be successful.

3. <u>Create design solutions</u>

   This part of the process may be done in stages, building from a rough concept to a complete design.

4. <u>Evaluate designs</u>

   The most important part of this process is that evaluation - ideally through usability testing with actual users - is as integral as quality testing is to good software development.

The process ends - and the product can be released - once the requirements are met.

This basic outline of the process is iterative and follows a simple cycle. It provides a framework upon which more complex design processes can be implemented. Details specific to individual projects can be included in this framework to develop more intricate, precise or even haphazard processes.

By focussing on the user, the goal of UCD is to maximise usability of the designed artefact. Dumas and Redish (1993, page4) emphasise the importance of the user when they describe usability as meaning “people who use the product can do so quickly and easily to accomplish their own tasks. This definition rests on four points:

1.) Usability means focusing on users

2.) People use products to be productive

3.) Users are busy people trying to accomplish tasks

4.) Users decide when a product is easy to use."

Here the term 'users' refers specifically to the actual users or representatives of the end user group, rather than those working with or around the end users such as supervisors or colleagues.

History

The term 'User-centred design' (UCD) first emerged in the 1980s from the work of Donald Norman at the University of California San Diego and was publicised in a co-authored book entitled : User-Centred System Design: New Perspectives on Human-Computer Interaction (Norman and Draper, 1986) and later developed in The Psychology of Everyday Things (Norman, 1988), in which he proposed four principles for design that place the user's experience at the heart of the design process:

1. Make it easy to determine what actions are possible at any moment

2. Make things visible, including the conceptual model of the system, the alternative actions, and the results of actions

3. Make it easy to evaluate the current state of the system

4. Follow natural mappings between intentions and the required actions: between actions and the resulting effect: and between the information that is visible and the interpretation of the system state.

To achieve these he suggested a move toward using the tacit knowledge of the user and away from the need for long unwieldy instruction manuals. The design should simplify the relationship between the user and the artefact, empowering them by allowing them to use their intuition. Norman's statements emphasise that UCD is about the designer understanding 'how' the user interacts with the artefact as much as about 'why' they do so.

Identifying the User

When placing the user at the centre of the design process, it is important to specify who the users are. Eason (1987) describes three types of user in the UCD process: primary, secondary and tertiary. Each of these is defined by their relationship with the designed artefact, and the designer must consider them within this context.

The primary user is the end user of the artefact. They will engage with it and use it most frequently and be the primary source of user information for the designer. The secondary users will use the artefact occasionally or through an intermediary. The tertiary users are those affected by the use of the artefact and might be involved in its purchase or maintenance. Eason's description takes into account a more holistic vision of the impact that the designed object will have on a wider community. Whilst not everyone within these groups need to directly inform the design of the object, their role in supporting the designed object should be considered.

Involving the User

Once the various stakeholders have been identified within a given design project, the next stage is to gather their expectations and requirements of the artefact through a needs analysis. This can be achieved with as much formality as the design team and users feel necessary and would typically involve gathering information through questionnaires, surveys and interviews, focus groups, observations and role playing. Whilst these are excellent practices for initiating a project, they may also be continued through the life cycle of the design, to maintain useful investigation and further develop ideas. In addition the design team may choose to invite representative users onto the design team to more closely inform the process. These members will be able to further contextualise the role of the user in relation to the proposed designed artefact. However it is important to remember that the longer they are involved with the design group, the further removed they become from future users with no prior experience of the product. It is therefore important to maintain user testing with the wider community.

Once the user requirements have been initially gathered, the designer can then start to produce responsive ideas to these findings. These may start very simple and gather complexity and form as an iterative process of user consultation and review is undertaken. Norman (1998) discusses the importance of knowing the user in order to be able to create designs for people, and emphasising their needs and abilities in order to improve usability and understandability. When discussing products, he criticizes the need for an extensive user manual, and instead suggests the design of artefacts that call upon the user's tacit knowledge of the world in order to make them understandable and useable. He also champions bringing the design object to the user within the environment where it will finally be used, in order that it is designed and tested in the context of the user's experience.

The designer must be receptive to user feedback and make observations on their engagement with the prototype in order to appropriately adapt the next iteration of the product. By engaging with this critical process the designer seeks to gain further understanding of the context that the design object will exist and be used in, and to extend and improve ideas that originated in the review of user requirements and needs analysis. As this process continues, the design of the artefact can be represented in more and more tangible prototypes that are moving toward the final product. As this happens the designer continues to work closely with the user to improve the usability of the object. This should take into account usability for all three identified user groups, who will have different interests in the product. For example the primary user may have no interest in the cost of powering an electrical product, whereas this may be of great importance to a tertiary user. The designer learns about these factors through engaging with their users and in doing so hopes to gain a more holistic view of their users and produce more rewarding products than they might in isolation.

User testing

This is argued to be the most important aspect of UCD. The user is directly involved in the evaluation of the product, and the designer has first hand user feedback to inform the iterative process. The usability of the product can be tested and improved. Employing real users to test the product is central to UCD and allows them to attempt tasks just as they would with the anticipated product. It also allows designers to build up a confidence in their product, by allowing them to see how it will be received by the end user. Traditionally, usability tests will take place in usability labs and be carried out by professionals in user testing who have access to the appropriate equipment needed, although mobile systems are also available. Methods of obtaining and recording data during sessions include interviewing, videotaping and questionnaires. These will usually occur during, as well as after, practical testing sessions although it may not be appropriate for the user to be consciously engaging with the feedback process at the same time as with the artefact.

The techniques of thinking aloud, in which the user talks themselves through the actions they are undertaking is an example of this.

<u>The Problem with User Centred Design</u>

The common problems identified with UCD are that it takes longer and may incur extra costs. In addition the creation of the design team can be more complex, as can integrating all the ideas from this team. Also, the product designed may be so specific to the user that it cannot be disseminated to a wider audience and this again adds to the cost implications of the project. Specifically if the product is only tested with a small number of the population this may not be sufficiently representative of the wider user base.

If usability testing takes place in a usability laboratory, it brings the user out of the environment in which they will finally be using the artefact, and may therefore provide unrealistic evaluation feedback to the design team.

<u>User Centred Design vs Activity Centred Design</u>

Norman raises criticism of the UCD approach arguing that the notion that the technology must adapt to the user is not always valid. Norman credits people with the ability to adapt, citing, at a fundamental level, the division of the year into months and days and hours as an artificial routine to which people have become accustomed. He argues that the user now eats at meal times, wakes to the alarm clock, attends classes or work for allotted time frames. All of these are out of sync with the user's nature - they may not be hungry, rested or receptive to knowledge - but yet they adapt to these requirements. From this artificial division of time have emerged the technologies of the clock and watch upon which all of modern human routine is dependent.

Similarly he gives the example of the motorcar as a technology to which people have had to adapt. Most cars have the same control scheme and yet many different people from all over the world learn to drive. The car, as with many day to day objects, has evolved around human beings over time, in this case taking its shape from a horse and cart. Norman calls this 'activity centred design' (ACD), a process that takes place "with a deep understanding of the activities that were to be performed", in which "the users were supposed to understand the task and to understand the designers' intentions". He gives the example of a violin, a musical instrument that can take years to master, but which the user accepts because they understand the activity and will adapt themselves to creating a harmonious relationship between bow, strings, body and sound. Similarly if one wants to learn to paint, one must gain an understanding of the tools and mediums involved; "it isn't enough to have an artistic sense".

> "To the Human-Centred Design community, the tool should be invisible, it should not get in the way. With Activity Centred Design, the tool is the way"
>
> Norman (2005)

In contrasting UCD with ACD, Norman highlights some of the potential dangers of UCD, primarily that when designing for the individual or individual groups, the artefact produced may be of little or no use to the wider community of users. As a result of tailoring design to one set of people it may be made worse for others. Also the requirements of the individual change over time. Therefore there is a risk of producing obsolete or soon to be obsolete designs. The user may quickly outgrow a design, and the designer will constantly have to adapt or redesign to meet these new requirements. More seriously, Norman argues, too much focus on the requirements of the user can be detrimental to the achievement of both the activity itself and the successful design of the technology.

He argues that UCD does not allow for the complex sequencing of operations that occurs in engaging in an activity. Rather it focusses on static elements within this process. Taking the example of the activity of cooking, many different operations must be achieved in sequence within the kitchen environment. UCD fails to support this type of behaviour whereas ACD focusses upon it.

> "Paradoxically, the best way to satisfy users is sometimes to ignore them."
>
> Norman (2005)

By responding to every detail of user feedback, the designer runs the risk of creating designs that are far too complicated, and that increase in complexity with every iteration, and thus loose understandability. This is particularly true when designing for a wide group of users and trying to meet all of their various requirements. Focus on the activity itself becomes lost, and therefore so does the original utility of the technology. However, by maintaining a clear and strong vision of the activity, the designer can continue to meet the needs of the user without necessarily responding to each of their individual requests. Norman defines this vision as the “Conceptual Model”. Without this the designer may either ruin the product by inconsiderately responding to user requirements or by creating irrelevant designs by ignoring user requirements and having no internal vision for the product.

Norman questions how much of the information gathered about the user is actually useful to and implemented in the final design, perhaps somewhat cynically suggesting that UCD runs the risk of paying lip service to both the user and the process itself. Furthermore he asks if any “major product” has emerged from a UCD process, and moves towards the conclusion that UCD is useful for improving existing designs rather than originating new ones and stating that UCD “does guarantee good results”, but not ‘great’ design. For ‘great’ design the designer must risk great failure and pursue their own vision.

Figure 3.2 - The components that make up an activity (Norman 2005)

Norman defines Activities as being made up of a hierarchy of processes. Activities are made up of Tasks; Tasks are made up of Actions; and Actions are made up of Operations. He stresses the distinction between the Activity and the Task, and gives the example of a mobile phone that supports communication activity through the various tasks of phoning, texting, exchanging photographs etc.

Discussion

In the early stages of Project Spectrum, a user centred design approach was taken in order to develop a rich picture of the requirements of a group of users who experiences ranged across the spectrum of autistic behavior. This was done through observation, semi structured interviews and questionnaires and these are discussed in greater detail in Chapter 3. Initially the user centred approach focussed on the requirements of the children, and these were elicited from parents and carers and when possible from the children themselves. The results of this enquiry formed the initial basis for designs from which the first prototypes were developed.

Eason (1992) describes three different approaches to user centred design, namely for users, by users and with users. Given the nature of the user group, this research began by designing for users based on the findings of the surveys taken. However, once the initial prototypes had been created, the next phase of the user centred process was to evaluate them, and this was done by taking them to the community, and to test them in the field. This gave the users the opportunity to experience and feedback on the designs, thus enriching further iterations of the design process with their suggestions. This engagement with the users was a valuable asset to the research as it allowed designs to evolve over which they had some ownership and knowledge of origination, which in turn would make the resulting artefacts more relevant and usable once they were completed.

Alongside the engagement with the users, the design was also informed by engaging with other communities who were able to inform the design process. This included fellow designers working with technology and with children; professionals working in special education; researchers working with children with autism; and members of the local authority supporting families affected by autism. Some of these could be categorised within Eason's (1987) description of three levels of user, whilst others could not. This research will argue in Chapter 3 that communities have informed the design process of Project Spectrum and not just users. User centred design alone was not sufficient in informing and supporting the creation of the artefacts produced during Project Spectrum.

The process of community centred design revealed new requirements, such as the need to locate it within a mainstream school, the need for it to be low cost and tailorable and the need for a facilitator who would work with the children. These in turn meant that the requirements of a new set of users also had to be addressed in the design which required a further investigation. To achieve this I engaged in a series of small projects in mainstream and special schools in order to gain an understanding of developing designs that could be integrated into an educational context and the requirements of the staff who would be supporting the use and maintenance of the artefact. These residencies also gave me the opportunity to continue user testing in situ, gaining first hand feedback from the users in order to improve the design during its iterative creation cycle.

In meeting the user requirements the decision was taken to use readily available technology rather than develop bespoke artefacts. This was in response for the need to produce designs that were both affordable and easily replicable. By using off the shelf technology, the equipment could be easily purchased by schools and maintained by existing members of staff such as the ICT coordinator. This shows how the project moves between user centred design and activity centred design, as a certain level of assumption is made about the tacit level of knowledge available within the school, and the ability of the users to adapt to the new artefact. In this case, the ability to operate a computer and simple user interface is assumed, and that familiarity with such a system makes it a more usable and less complex proposition than creating a new user centred design. Also it means that the artefact will be more readily available to a wider group of users as training needs will be minimised. The result of this should be that more time can be spent in addressing the requirements of the children engaging with the artefacts, and less addressing the requirements of the facilitator and other users supporting this work.

3.2 Educational ergonomics and the Hexagon-Spindle Model

Introduction

The user centred design approach taken at the start of Project Spectrum revealed the need to deliver the work within a mainstream school. This setting would ensure the professionalism and consistency required in providing the experience of the interactive digital modules to the children, and would allow access to a wide number of the local community. It would also provide a model for integrating this type of work that was replicable in other schools. As discussed above, this revealed a new set of user requirements to the project, and to meet these the work now had to be considered in the context of being integrated into the day to day life of a school. In order to achieve this, the research considered how the use of a model of educational ergonomics could be applied to further the delivery of the designs.

History

The concept of educational ergonomics was introduced by Henry Kao (1976). His view was that an educational institution was essentially a work system "where the objectives include successful dissemination of knowledge and cultivation of intellectual sophistication." This application of ergonomic work systems to education helped him to outline an interdisciplinary field of educational ergonomics. The definition has been further clarified by Woodcock (2007), who distinguishes two strands of practice, both of which are termed 'educational ergonomics'. The first of these deals with the teaching of ergonomics and the other with the design of environments where teaching and learning occur.

The concentric and enhanced concentric rings model

The concentric rings model of ergonomics (Galer, 1987) places the worker at the centre of activities, and shows how they interact with the various tools and co workers which make up their work interface. These interactions are subject to influence from elements that directly concern the worker such as equipment, training, fatigue etc, further out from elements of the wider work area such as colleagues and the layout of the environment, and further out still from broad changes at society level such as economic and cultural patterns. Each of these rings of influence affect each other and the system as a whole, thus manifesting in the quality of the work produced by the worker.

The enhanced concentric rings model (Figure 3.3) (Girling and Birnbaum, 1988), went on to further sub divide the rings of influence to acknowledge that the source of a problem could be the result of management of the organisation, the context of the task at hand or the individual(s) attempting the task. These are represented as differential sectors that allow problems to be described as organisational, situational or individual and assist in diagnosing when multiple sources exist for a design problem.

Figure 3.3 - The enhanced concentric rings model (Girling and Birnbaum, 1988)

The Hexagon model of educational ergonomics

By applying Kao's approach of mapping notions of work to those of education Benedyk et al. (2009) argue that the term 'work' be replaced with 'learning', and that the ‘workplace’ be substituted with ‘educational environment’ in which the learning ‘tasks’ will take place. A series of learning ‘tasks’ go to make up the learning ‘work’. The learning ‘task’ is undertaken by the ‘learner’ or student during a dynamic exchange of information with either another student or a teacher or with learning objects such as textbooks or technology. These learning exchanges can take place in a variety of environments, formal such as the school, or informal such as a cafe.

Benedyk et al. go on to argue that the characteristics of the educational environment are not easily addressed by the traditional work systems approach to educational ergonomics. Firstly there are usually two distinct groups of workers, these being students and teachers, and their tasks are co-dependent, with the success of either being directly linked to the other. Secondly the ages and needs of the students can vary enormously. Thirdly the work they participate in together can occur simultaneously or at different times, and within the same or different locations. And fourthly there is no standard method of education, with groups learning in a variety of formal and non formal scenarios and employing a range of different facilities for learning, including portable devices and online resources. Each of these factors confounds the traditional model of educational ergonomics.

The Hexagon Spindle model of educational ergonomics was developed by Benedyk at University College of London, working within the Department of Psychology and Computer Science, and specialising in Ergonomics; and Woodcock at Coventry University, who is Leader of the the Design and Ergonomics Applied Research group and was Principal Investigator of Project Spectrum. Woodcock introduced the model to the research team leading to its application to Project Spectrum and later to the publication of Woodcock, Benedyk and Woolner (2009). Before this, the model had not been applied to educational environments. Additionally a noted change in the model, through its application to Project Spectrum was the introduction of the spindle, to denote change of environments, working contexts and user characteristics through the course of the day.

The Hexagon-Spindle model of educational ergonomics (Figure 3.4) proposed by Benedyk et al. (2009) builds on the enhanced concentric rings model to provide ‘a structured task-based approach to the learning environment’, and again places the learner at the centre of events, surrounding them with the factors they engage with either positively or negatively throughout the learning task. The workplace however is not confined to the workstation or desk of the worker but now encompasses the whole 'learning environment', and this is reflected by redefining the 'workplace environment' as both the 'workplace' and the 'work setting', with setting being any formal or non formal learning environment that the student chooses. The model also acknowledges that the influence of various factors are dependent on the task at hand, and that for any one task the student is interacting with all three tiers of influence. Benedyk gives the example of a school pupil who is learning gymnastics and interacts directly with the gym equipment, with the exercises set by the teacher and with the gym facilities and procedures set by the school, with their classmates and with their own fitness and attitude to exercise. Each of these factors can affect the learning of the pupil.

Figure 3.4 - Overview of the Hexagon Model of the Ergonomics of Learning Environments, Benedyk et al. (2009)

Key to the Hexagon-Spindle Model is that it recognises that learning takes place over time and that one student can participate in various learning events that take place in sequence across different learning scenarios each with distinct characteristics. Each of these learning events is represented in the model as one of the hexagons, with the spindle (Figure 3.5) representing the passage of time from one to the next so that the model comes to represent a cross section of the students experience across one day. The events of each hexagon therefore have an influencing factor on those that follow. This allows us to examine how the educational experience of individuals is formed.

Figure 3.5 - Depiction of Build up of Learning Tasks on the Time Spindle, Benedyk et al. (2009)

It is believed (Woodcock et al. 2009) that the model will provide opportunities for ergonomists to become involved in the design of learning environments "by providing the holistic overview sometimes lost in planning stages and a more structured approach to the consideration of the human factors that affect leaning interactions". It may therefore be a suitable tool to consider when considering design for children with ASD, as not only does it place the child at the centre of the process, but also acknowledges the need to consider the child's experience throughout the day and how this can affect their use of a bespoke environment and digital modules. Being able to evaluate their experience holistically allows the designer to consider the needs for predictability and consistency that have been brought out in the literature review, as well as specific relationships with environments and individuals which can be so important in determining how a child engages with artefacts designed for them.

The implications of this are discussed in greater detail in Chapter 7 in which the evaluation of Project Spectrum is discussed.

Discussion

Applying the Hexagon Model to Project Spectrum allowed the child to be placed at the centre of the model, and for the context of their experience within the designed environment to be visualised. Within the central hexagon the learner characteristics were informed by the user centred research undertaken at the start of the project and supplemented by the subsequent community centred research. These provided a range of sensory needs that the environment would have to accommodate. A wider range of factors that influenced the child's experience were also gathered through parent's providing 'day in the life' diaries, discussions with the local authority, residencies at schools catering for children with ASD, and conversations with families of children whose education had been affected by ASD. All of these illustrated the need to account for a wider range of factors than just the experience that took place within the designed environment and are shown here (Figure 3.6), mapped onto the outer levels of the Hexagon model.

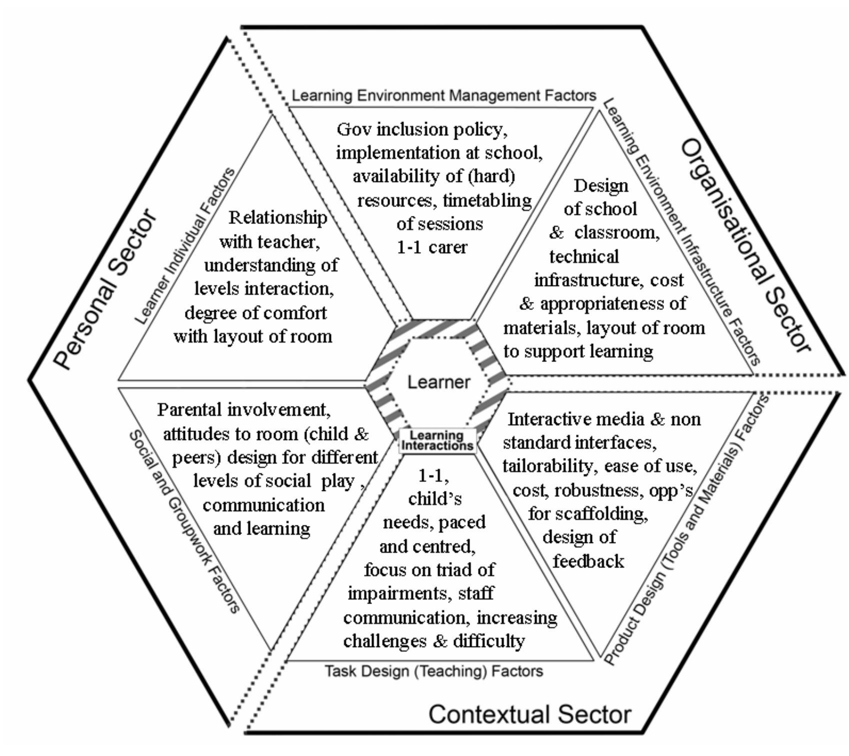

Figure 3.6 - Requirements from Project Spectrum mapped onto the Hexagon Model, Woodcock et al. (2009)

(Woodcock et al. 2009) describes the application of this ergonomic model to Project Spectrum in detail and is included here in the Appendices.

3.3 Action Research

Introduction

Having taken a user centred approach to the initial gathering of requirements, early prototype designs had been developed. As part of the iterative process of user centred design these prototypes were now to be tested. This involved making contacts within the autism community who were willing to engage with the project, and subsequently working with them to test, discuss and improve designs. A process of action research was entered into, which went on to become part of the model for community centred design.

Definition

The term 'Action Research' was first used by Lewin in his 1946 paper "Action Research and Minority Problems", in which he describes the process as "a spiral of steps, each of which is composed of a circle of planning, action, and fact-finding about the result of the action." He used it to explore the effects of and moves toward social action. O'Brien (1998) offers a simplified definition as "learning by doing - a group of people identify a problem, do something to resolve it, see how successful their efforts were, and if not satisfied, try again." He defines the researcher's role as "to nurture local leaders to the point where they can take responsibility for the process"… "and are able to carry on when the initiating researcher leaves.". This involvement of participants is more explicitly identified by Lomax and Parker (1995: 56) who employ the following six principles to define Action Research:

1. Action research is about seeking improvement by intervention.
2. Action research involves the researcher as the main focus of the research.
3. Action research is participatory and involves others as co-researchers rather than informants.

4. Action research is a rigorous form of enquiry that leads to the generation of theory from practice.
5. Action research needs continuous validation by 'educated' witnesses from the context it serves.
6. Action research is a public form of enquiry.

<u>Process</u>

Action research is an iterative process that allows a problem to be continually revisited and assessed in the light of knowledge gained from action taken. Susman (1983) presents action research as a five phase cyclical process which is adapted in the following diagram:

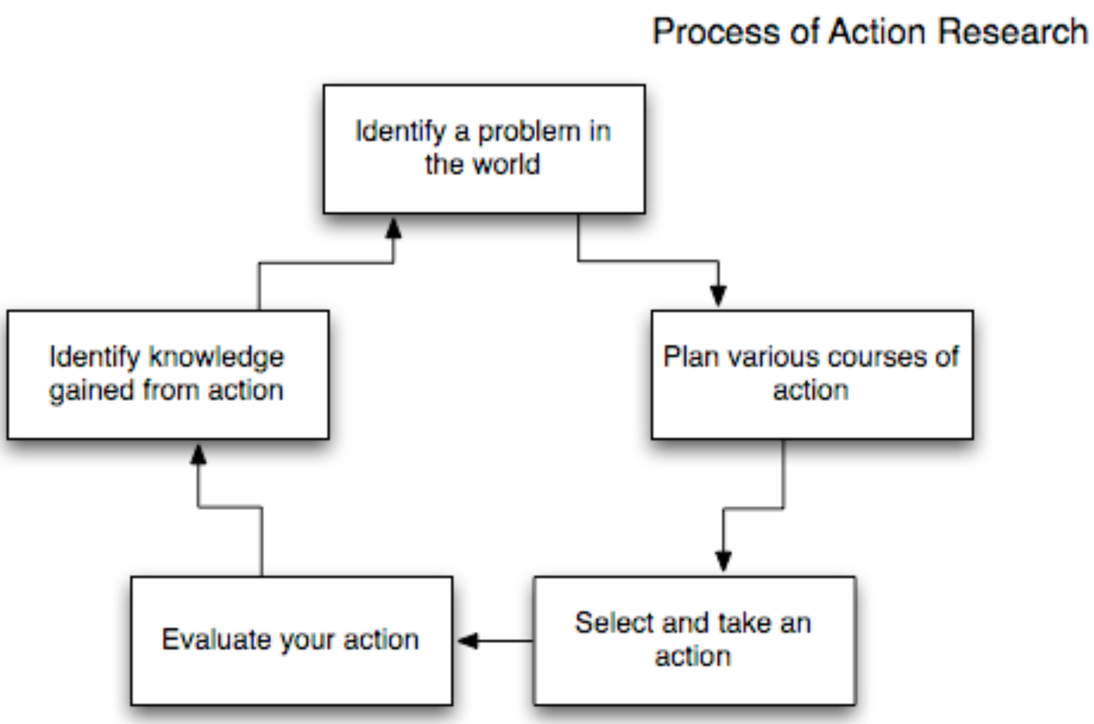

Figure 3.7 - The process of action research, adapted from Susman (1983)

This shows the movement from problem to planning to action to evaluation to knowledge which can then be recycled into the understanding of the problem.

The action researcher partakes in the action for change as well as in the research, planning of and reflection on that action. Likewise the participants in the action become researchers themselves, learning from the action they are involved in. This is a social process that aims to solve real world problems involving both the scientifically trained researcher and those facing the problem. Unlike many other research processes, the researcher does not take an objective role, but joins the participants in the move for change, and the participants are given the opportunity to stand back and objectively reflect on their actions. There are two primary outcomes to the process, the first is that the problem is solved or there is a movement toward a solution. The second is the furtherance of the research process and the knowledge that underpins it.

Winter (1989) offers six principles that should underlie the process. These are summarised here and briefly contextualised within this research:

1. Reflective critique.

The researcher(s) reflect on information gathered during the process in order to identify assumptions and bias in assertions made by informants. It is understood that the 'truth' of information is relative to the teller and their circumstances within the identified scenario. This is different to Schön's reflective practice (see below) in which the researcher examines the tacit knowledge behind their own actions.

2. Dialectical critique.

The researcher(s) have a critical understanding of the language used to describe phenomena in order to build up an accurate understanding of the descriptions used by participants. Throughout Project Spectrum (Woodcock et al 2006) this was necessary between the designer and the participants and also between the designer and his colleagues from the project team.

3. Collaborative Resource.

Each participant is a co-researcher and their ideas are equally important in informing the research process. A model for community based research was developed during Project Spectrum. The model allows design to draw on the knowledge of individuals and teams from a range of communities, and acknowledges the importance of equality in the opinions of each stake holder.

4. Risk.

Action Research initiates change over the previous order. The fears of participants are allayed by the movement towards new knowledge through the open discussion of ideas by all. Project Spectrum (Woodcock and Georgiou, 2007) had the ambition of informing theory, practice and policy at school, community, sponsorship and policy levels. The community centred approach taken in the development of the project allowed multiple stake holders to share discussion and to engender change. This process was represented in the artefacts created, their presence in the communities and the awareness they raised of the issues being discussed.

5. Plural Structure.

Action research reveals multiple opinions and critiques that leads to many possible actions. This dialogue is continued through the research process rather than resolved with a conclusion. Project Spectrum (Woodcock and Georgiou, 2007) created and employed designs and approaches that would inform and be superceded by future research. The project “evoked and focussed activity which results in the identification of further design goals”.

6. Theory, Practice, Transformation.

There is a reciprocal relationship between research and practice, as each refines the other. Both are aspects of the same movement toward change. The researcher(s) justify actions through theory and refine theory through practice. The iterative process of design employed in Project Spectrum (Woodcock and Georgiou, 2007) began with a review of existing theory in order to inform initial practice and prototypes, evaluation of which then contributed “to a reflection of all stages, including the initial conceptualization of the project - thereby challenging initial research assumptions and beliefs.”

<u>Discussion</u>

By becoming involved with the autism community, I started to ‘partake in the action for change’. In identifying common goals between the Project Spectrum team and the autism community, the two were able to work together in realising the delivery of the designs. Bringing the project to the community presented them with a new context for their requirements, and a vehicle with which to see them realised.

This synergy provided the momentum for the move toward change, and afterwards gave each participant the opportunity to reflect on their actions within the structure of the project evaluation.

As action researcher, my role entailed a journey between various members of communities, gathering and disseminating information that would help to initiate change through the creation of Project Spectrum. With this clear goal it could be argued that I was the 'focus of the research', as I came to represent the project to each of the communities and my identity became associated with this work. However I would argue that this is slightly misleading as from my perspective as action researcher, the focus of the research was the realisation of the project and its success amongst the community of users. This was the joint endeavour, and my role was to act as a catalyst to its creation. This is reflected in the emerging model of community centred design (Chapter 4), which places the designer at the centre of the process, and acknowledges their role in iteratively bringing together the knowledge and resources of various communities in the production of designs.

3.4 Reflective practice

The action research approach adopted throughout the research was complimented by continued reflection on practice in order to guide future work. This reflection was shared with other members of the research team, helping to generate the ideas that led to further iterations within the design. This process of reflection in and on practice is distinct from the critical reflection used to distinguish 'truth' from the accounts of users within action research.

Reflective practice concerns the relationship between the thinking that occurs before, during and after the actions that we perform and the actions themselves (MIT 2007). The term was first used by Schön (1983) whilst working at MIT, who applied the approach mainly to the development of education in professional schools. Subsequently the approach has been used by practitioners in a number of fields including design, engineering and medicine. The goal of reflective practice is to continually renew our research theories in order to be able "to dialogue with the disruptive changes that the future will bring to our lives" (MIT 2007).

Schön presented reflective practice as a critique of technical rationality which stated that 'problems are solved by the adequate use of the adequate theory' (MIT 2007). Schön argues that society's most relevant problems are in messy situations where research based theories do not apply. The problem may be new or badly defined and existing research theories will not be relevant to it. Professionals therefore require an artistry that goes beyond a theoretical basis and their actions will not always be in accordance with formal theories. Rather the theory exists tacitly within the actions of the professional. This 'theory-in-action' is distinguished from the explicit 'espoused theory' which is used to explain the action to others. Reflective practice is about our awareness of our tacit knowledge and how we use it to improve our actions.

Schön argues that the knowledge that we use to perform everyday tasks and that professionals use in their practice is tacit, describing it as 'knowledge in action'. The thinking that takes place about our actions is 'reflection on action', and through this process the researcher reflects on the tacit knowledge he has used to perform a task, thus moving to make the implicit explicit in his understanding which he then "surfaces, criticises, restructures, and embodies in further action" (Schön, 1983 p.50). This is called 'reflection on reflection in action'. Through this process the practitioner evolves the tacit knowledge that they will employ in future actions and according to Schön their method for dealing with "situations of uncertainty, instability, uniqueness, and value conflict". Scrivener (2002), describes this iterative process for the practitioner as spiraling "through stages of appreciation, action, and re appreciation, whereby the unique and uncertain situation comes to be understood through the attempt to change it, and changed through the attempt to understand it."

Reflective practice shares many characteristics with action research (Valero and Zevenbergen, 2004) as they both involve the practitioner in developing the relationship between their theory and their practice, requiring a level of reflection in developing this synergetic process. McMahon (1999) distinguishes the two by arguing that action research involves "a deliberate and planned intent to solve a particular problem - or set of problems. By its nature action research involves 'strategic action'." This can be contrasted with Boud et al's (1985) description of reflective practice as 'an active process of exploration and discovery which often leads to very unexpected outcomes.'

Discussion

Reflection was used throughout the evolution of this research, and its role in Project Spectrum and the development of the model for community centred design is discussed in greater detail in Chapter 4. From the outset, reflection on previous work was used to inform the early stages of this research, and this, coupled with the initial user requirements, formed the basis upon which new designs began to be created. From then on an iterative cycle of reflection was entered into (Figure 4.3), and this became integrated into the community centred research process (Figure 4.4). As part of the action research, members of the communities involved in the project, participated in the reflection process, and the designs would take these reflections into account. This included reflection before the development of the final artefact, which served to inform its design, and reflection on the use of the final artefact which informed its evaluation.

Finally, reflection has taken place in the writing up of this research and the dissemination of its findings, which in turn has gone on to inform future work in this field.

Conclusion

This chapter has discussed the design methods and theories that have been used in the realisation of the artefacts and design models produced as a result of this research. It has defined user centred design and activity centred design, and discussed their application to this research. In particular it discussed how user centred design was used to elicit initial requirements for the design of Project Spectrum, and how this led to the recognition of a wider group of users. In working with this wider group it became apparent that it was not just primary, secondary and tertiary users who would inform the design, but a wider range of communities. This initiated the need for a new model of community centred design.

The chapter then went on to discuss educational models of ergonomics, and the need to contextualise the research within the setting of a mainstream school. The evolution of the Hexagon Model of ergonomics and its relevance to Project Spectrum were detailed. This was followed by a description of action research and its application to Project Spectrum. This included a discussion of its role within the development of community centred design.

Finally the chapter discussed the significance of reflective practice and how this occurred alongside the other methods to enrich the design process. This chapter concludes the literature review and Part 1 of the research. Part 2 describes the application of this research to Project Spectrum, and Chapter 4 demonstrates in more detail how the design methods discussed here have been employed to deliver the artefacts created.

Part 2

Introduction to Project Spectrum

In 2003, the Arts and Humanities Research Council (AHRC) awarded Coventry University grant number B/RG/AN9131/APN16454 to fund two research assistants, myself and Jacqui Jackson, to undertake a research project into the development of a sensory environment that employed digital technology to engage children on the autistic spectrum. As part of this project, the grant funded both researchers for three years to begin their doctoral studies. This research comes as a result of that study. The first part of the research presented a review into the literature and practice that has informed the research. This second part explains how that research has been applied in the development of Project Spectrum to meet the funding requirements of the AHRC.

The objectives required to develop Project Spectrum as submitted to the AHRC were to:

1. Understand the requirements of autistic children, their teachers and carers

2. Develop a general purpose methodology enabling such requirements to be captured and embedded in software design

3. Develop an adaptable, interactive digital environment, tailorable for those with an ASD

4. Develop an evaluation methodology based on diagnostic responses to assess the extent to which the environment meets the needs of the child, carers and teachers.

My primary role in Project Spectrum was to meet the 3rd objective, and in doing so it was also necessary to address the 1st objective. These are the focus of this PhD and have been subsequently broken down into the objectives on page 6. The 2nd and 4th objectives are not discussed in detail here, as they form the subject of Jackson's dissertation (2009). Jackson's work also established a preliminary set of requirements. These are alluded to in this thesis, with a clear distinction being made between the received requirements and those developed through my engagement with the community. The final project was rated as 'outstanding' in reviews from the AHRC

The following diagram (4.1) illustrates the timeline for Project Spectrum, beginning with the assembly of the project research team and culminating in the evaluation of the final work and the subsequent creation of a portable version of the project. The timeline shows how the work progressed from a study based within the University with a small team of researchers to become an artefact that was delivered within a much wider community. This evolution occurred as a result of the action research stance that I adopted, and the development of contacts within the community which is discussed in greater detail later in this chapter. The action research consisted of site visits; meetings with members of the community including parents, children and carers affected by autism; interviews with professionals working with children with autism; interviews with fellow designers and academics in the field; conferences; and a continued review of the existing materials.

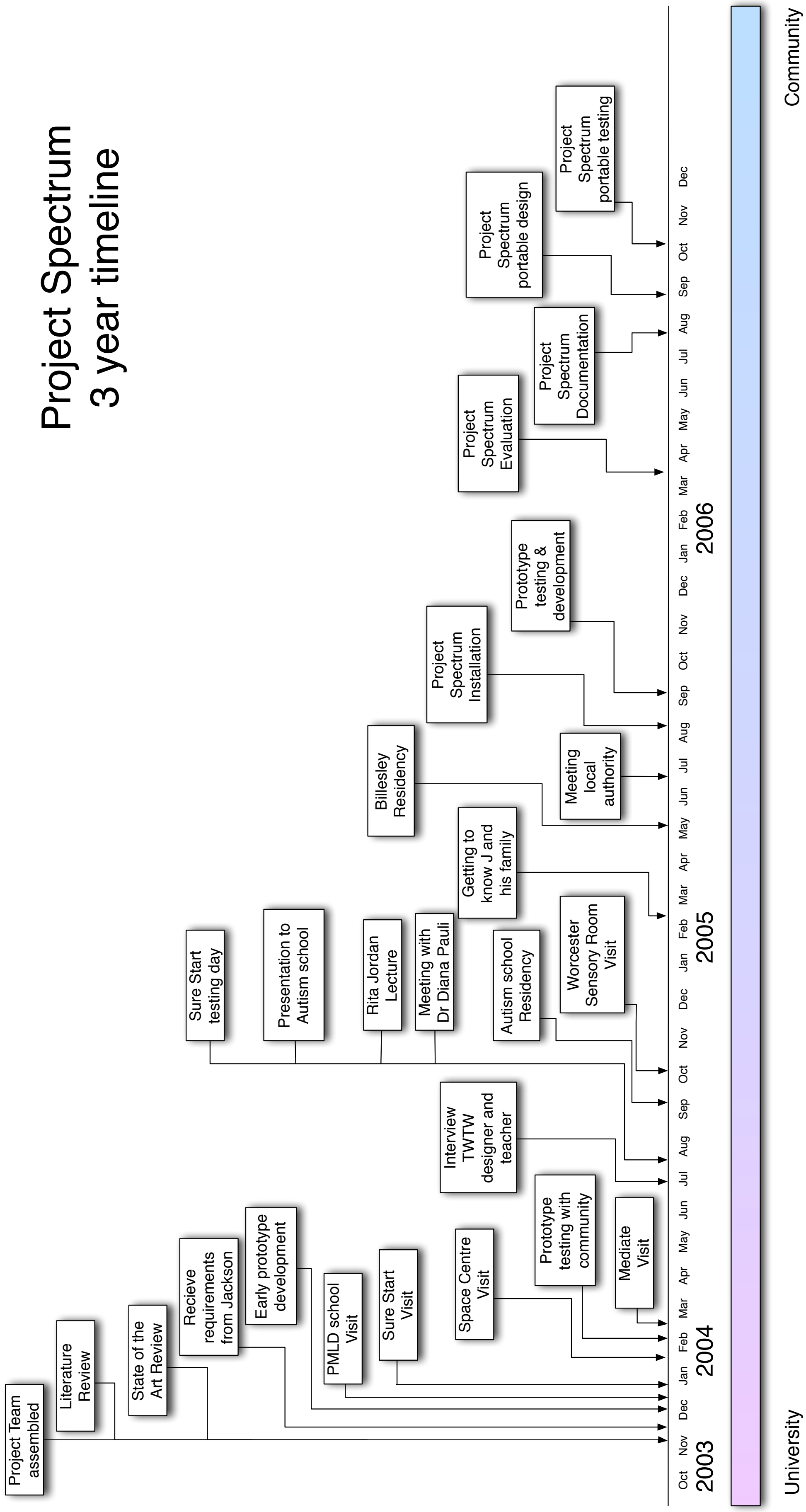

Figure 4.1 - Project Spectrum 3 year timeline

Chapter 4 - Eliciting User Requirements

Introduction

This chapter discusses how user requirements were elicited in order to inform the design of Project Spectrum. This involved engaging with communities of people whose lives have been affected by autism. The chapter begins by presenting Jackson's findings (2009) that were used to begin prototype design development. It then goes on to discuss the rationale for and methods used in my own action research to give greater depth to my understanding of the user requirements. This includes discussion of the development of a new model for community centred design, and its application to Project Spectrum. This design process answers one of the main objectives of this research. Following this are examples of the community based research undertaken. This includes meetings with parents and children, teaching staff and carers, fellow designers and other practitioners in the field.

Following this a selection of prototype testing occasions are described. These helped to clarify the design of the prototypes and environment by bringing the prototype to the community for practical testing and constructive criticism.

Received requirements from Jackson

In order to gain an initial understanding of the requirements of the user group, the team undertook data gathering including observation, semi structured interviews and questionnaires. Jackson developed a web based questionnaire to ascertain the sensory requirements of the children, with children being grouped as either lower or higher functioning depending primarily on their level of communication skills. The higher functioning children included those with Asperger's syndrome. Whilst autism is a spectrum disorder some (Bartak and Rutter, 1976; Gaffney and Tsai, 1987) have taken to using a classification of higher and lower functioning autism based on whether the child has an IQ of above or below a particular number. This number varies between practitioners and is not a scientifically recognised diagnosis. It does however indicate a need to diversify the diagnosis of autism to recognise difference in ability across the spectrum. Jackson (2009) argues that even the most skilled clinicians cannot predict where a child with an ASD should be placed on the spectrum. For the purposes of this research she therefore identified two categories of child, the first being those with a primary diagnosis of autism and little or no speech; the second having a primary diagnosis of Asperger's syndrome and a level of speech capable of carrying on a conversation, including asking and answering questions.

500 responses were received which illustrated trends in the preferences of these two groups. These findings were corroborated and clarified by the observation of eight children from different areas of the spectrum encountering a typical snoezelen sensory environment. A further 25 semi structured interviews were carried out, 15 with parents of children on various areas of the autistic spectrum and ten with teenagers with Asperger's syndrome or high functioning autism. Finally a 'day in the life' observational diary was created to illustrate how ASD can affect a child and their relationships with their environment.

The following table illustrates the quantitative data gathered through this initial research process which shows that children with an ASD experience sensory difficulties with olfactory, tactile, vestibular, auditory and visual processing. This research forms the basis of Jackson's PhD (2009) and so is not discussed in detail here.

Table 4.1 - Preferences received from Jackson

	Lower functioning children	**Higher functioning/ Aspergers**
Likes	Red	Blue
	Round Shapes	Circular shapes
	Nursery rhymes, meditation music	Rock / pop music
	Smooth, soft and downy textures	Smooth, soft and downy textures
	Mirrors	Projected light effects
	Soft play areas	Soft play areas
	Sound / light equipment	Sound / light equipment
Dislikes	Sticky, slimy or prickly textures	Sticky, slimy or prickly textures

	Lower functioning children	Higher functioning/ Aspergers
	Loud noises	Loud noises
	Sensitivities to smell	Smells and certain lighting
	Interaction with others	Interaction with others

In addition it was found that:

1.) Colour is of great importance to children on the autistic spectrum and could have a bearing on their mood or behaviour. Red and blue emerged as two favourite colours.

2.) Most parents commented on how their child enjoyed spinning. This could be either of themselves or an inanimate object, or how they liked to watch objects that spin. This correlated with the preference for circular shapes that emerged from the questionnaire.

3.) Many of the children in the higher functioning group had difficulty with coordination, whereas those in the lower functioning group had a need to repeat certain movements and showed distinct patterns of movement.

4.) There was a need in both groups to gain control over their environment.

5.) There was a need for predictability in both groups

6.) There was difficulty with interaction in both groups

The observations made of children using a traditional snoezelen environment revealed that they both enjoyed the experience and found it relaxing. However there was a notable change in behaviour caused by changes in lighting in both children with Asperger's syndrome and classic autism. Children could become hyperactive and overstimulated by the environment, some becoming aggressive for the rest of the day. It was also observed that they relaxed during tactile stimulation from immersion in a ball pool, or being squashed under bean bags.

The 'day in the life' accounts highlighted the need for predictability in the child's routine and the changes in behaviour that could occur if this was not provided. They also illustrated the importance of screen based media for the children – with both television and computer games playing a significant role in recreational time. It was commented that the only time two of the boys played together, rather than in parallel, was when they used a Sony playstation 'eyetoy' and the various camera based games it offered, allowing the children to see each other on the screen. These children experience different sensory preferences with one preferring loud noises the other not liking them, and one having a favourite colour of red, whilst being terrified of it when encountering it in television programs. This illustrates how individual the requirements of the children can be. Importantly this research also indicated the need to have a regular, easily accessible experience, that could form part of the 'normal day'.

Building on the literature review

The literature review furnished me with a theoretical understanding of autism, and the dialectical critique (Winter 1989) to be able to discuss the subject with experts in the field. Having regular and frequent meetings with Jackson helped me to further my understanding of the vocabulary used when discussing autism, and gave me experience of the issues commonly faced by both children and parents affected by the condition. This helped to prepare me for meetings with parents, teachers and carers, giving a reference point from which to develop knowledge in the field.

Jackson's research provided a good starting point for initial designs, suggesting colours, sounds and shapes that might be used within the interactive modules, as well as methods of engagement such as movement, and the need to develop something that was controllable and predictable. However I felt that whilst her results showed trends in preference, to limit my designs to these might alienate members of the community with different preferences. For example her results suggest a preference for either blue or red amongst the two groups. During a discussion I had with some boys on the autistic spectrum they expressed a preference for green. It was therefore important to maintain the vision for a tailorable environment that took advantage of the ease with which a computer system can change parameters to suit individual users. Jackson's findings would therefore be embedded in the software as initial settings, with users able to alter these easily to suit preference. For example, the trails module (described in Chapter 5) defaults to a 'red' setting, but can easily be changed to other colours. The spots module defaults to round shapes and soft sounds, but can be changed quickly by the facilitator.

The Project Spectrum team was based at Coventry University, and it was here that much of the early planning of the project took place, including the sharing of design ideas and user requirements between myself and Jackson. The project therefore began with academic characteristics, which while useful in creating a framework for the research, did not provide a real world understanding of the users, nor participants for user testing. Jackson had several contacts in the autism community, however these were not local to the University. It was therefore necessary to develop the project within a community that was accessible to the project, and which could provide real world feedback on the designs. This would also help to generate further requirements and to more fully contextualise those provided by Jackson.

Developing a new model for community centred design

Taking the lead from an initial contact passed to me by a fellow artist, I started to develop links within the local autism community. These included parents, carers and teachers through whom I was able to meet with the children themselves. It also included fellow designers and researchers working with interactive technology and with children with autism. To gather this research, I undertook three methods:

1.) User Centred Design

2.) Action Research

3.) Reflective Practice

each of which was incorporated into an iterative cycle. By engaging in these processes in tandem, a new model for community centred design emerged. This model understands communities to be distinct groups of people each with their own practices and interests. These communities become linked by a design project from which each stand to benefit, and to which each can impart valuable knowledge.

The communities are identified through a process of user centred design that firstly recognises a problem that requires a design solution, and then contextualises it by discovering who will use the artefact produced and who will support them in doing so. Eason (1987) suggests that there are three levels of user, primary, secondary and tertiary, each of whom will be involved with the use of the artefact at different levels. The model of community centred design presented here argues that these users are scattered amongst various communities, and that it is the role of the designer to identify them, to discover their requirements and to map these into the designs produced. In addition a community may not hold any end users, but will inform the design process, and or be affected by the outcomes of the design.

For example, during Project Spectrum, designers working with digital technology in different fields showed interest in the project and gave suggestion on how it might be realised, whilst playing no role in its final delivery. Following the project, designers working with digital technology can take inspiration from the work and develop their practice toward developing future work for children with ASD. Likewise, academics who have suggested methods of completing the research can take advantage of the research emerging from the work, whilst not having a direct role as a user of the artefact. The model allows for the requirements from each community and from each level of user to inform one another, with the designer recognising the potentials for synergy and conflict and adjusting designs accordingly.

This is an active process that draws on action research practice, by placing the designer at the centre of the process, and entrusting him to move between various communities to identify aims, requirements and limitations, and to reconcile these into design. In doing so he starts to produce designs which are taken to the communities, and with each visit these are refined and improved upon and the responses of users become integrated. The designer takes an egalitarian view of all the users, understanding that the knowledge of each one provides an expertise in a particular area, and that each provides an essential link toward a successful design. For example, Project Spectrum could not have proceeded without the backing of an external funding body and could not have been completed without the support of members of the autism community. Whilst these two communities never met each other over the course of the research, I was responsible for ensuring that both of their needs were met in the delivery of the project.

As I gathered research both through action research and a continued review of the literature, I was able to reflect upon it and develop and modify designs. This was a collaborative process in which findings were shared with both the university team and the local community to gain further perspectives. Being the chief representative of the University team amongst the local community meant that I was tasked with the role of presenting ideas from both groups and returning feedback. This gave me a unique perspective on the project, and allowed me to shape designs that met the project remit, deliver them in a real world scenario and evaluate them with members of the local community. Developing designs that were relevant to the community and bringing new artefacts to them also helped to prolong the legacy of the project beyond the lifespan of the academic study, and to disseminate the results amongst a wider group of people (Woodcock and Georgiou 2007).

The emerging model of community centred design, which acknowledges the designer as the gatherer and disseminator of knowledge between the communities, illustrates how a project moves in an iterative cycle from its conceptual origin to its practical delivery, and how this entails a movement outward from the inception of the work within an individual or small community, outward to a wider group of communities. In the case of Project Spectrum this involved a movement from an internal academic community to an external real-world community.

The model acknowledges that during the life-cycle of a design project, the interests of several parties need to be met, including funders and institutions, as well as end users. It also states that once a project has left the more formal and structured environment of the planning phase and ventured into the outside community, one must allow for serendipity to occur and for the work to take on a life of its own, as defined by the users who engage with it, see new potentials for it and begin to adopt it into their daily experience. Fundamentally it places the designer at the centre of this process, and argues that they are the conduit for the project rather than the owner. Ownership moves from the originating community to the communities of users as the artefact takes form and is realised through an iterative process of design and testing. This first part of this model and its application to Project Spectrum is illustrated by the following diagram:

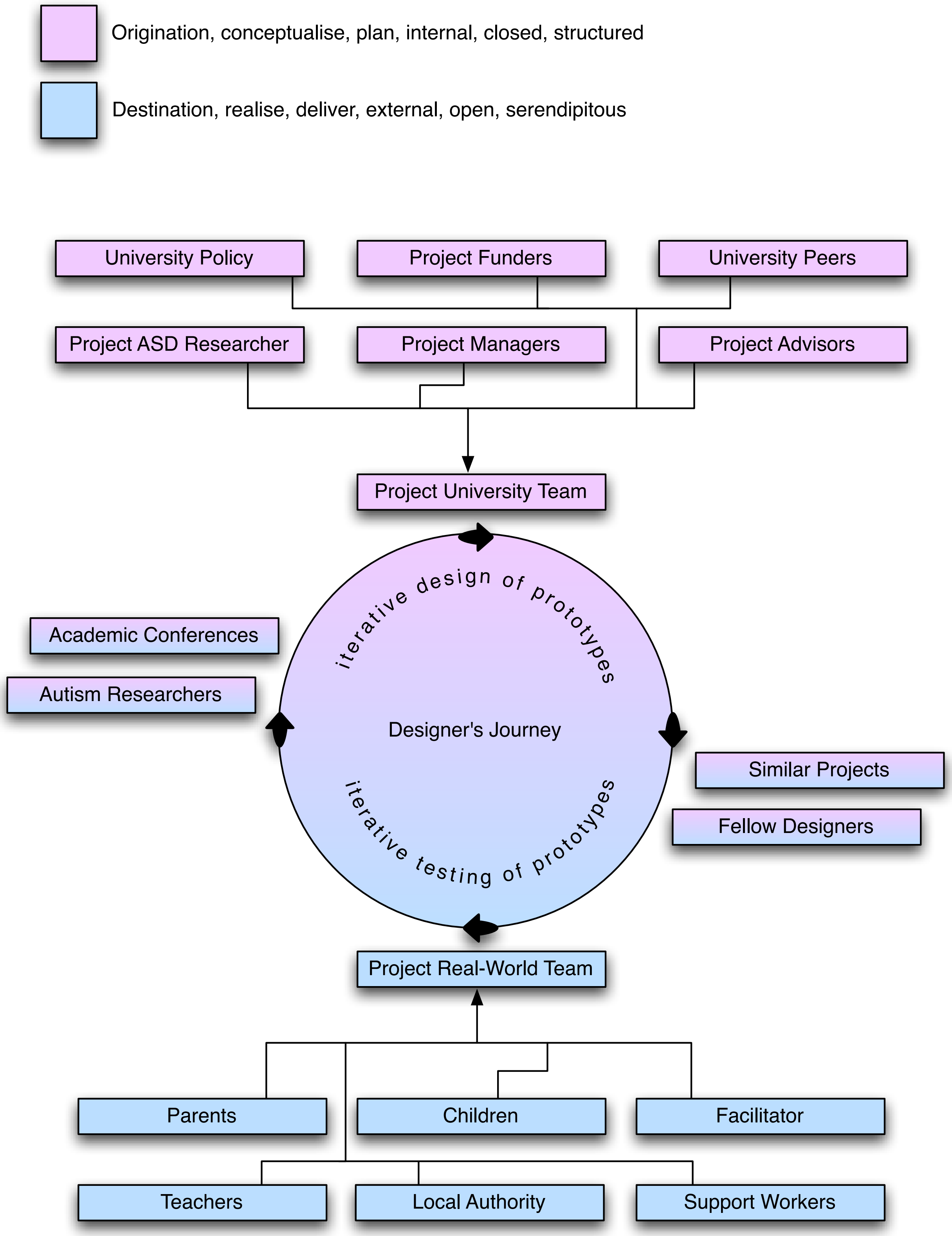

Figure 4.2 - Community centred design - part 1

The importance of reflective practice in the design of Project Spectrum

While the above model for community centred design illustrates the cyclical and holistic nature of design projects such as Project Spectrum, it does not account for the reflective nature of the designer's task. This is a central part of the process and completes the model above. Because of the importance of its implications, it is discussed here independently.

The action research of the designer is subjectively processed through reflection. Whilst reflection may occur alone or during encounters with others, it is ultimately an internal process which assists the designer in making decisions and furthering the project. As the designer engages with the various parties involved in the project, he brings with him knowledge and ideas that he has already assimilated into his understanding of the design task. These may be recent developments or legacies dating back to the project's inception. For example these might include new knowledge of the user requirements, suggestions for locations for prototype testing, possible sources of increased funding, a recent visit to an academic conference. Each of these might be considered as immediate concerns, ongoing and less pressing issues or even ideas that the designer has judged to be unimportant at this time.

This is an ongoing process that involves both reflection in and on action (Schon 1983, Scrivener 2000), both of which may occur in tandem. For example the designer may be meeting with the project team to discuss findings from prototype testing in the community. This will involve reflection on action, as he presents and looks back upon previous work. However, his discussion with the project team, and his engagement with their responses to the work, will involve reflection in action, as he draws upon his experiences and knowledge to interpret and include their ideas. This may then be followed with further reflection on action as he assimilates new ideas presented into the design project, and may also include reflection on reflection in action, as he re examines how the reflective process that took place during the meeting directed its outcomes.

This example demonstrates that not only is reflection subjective, but also that within this is the opportunity for other people and events to influence the reflective process. Following this, the designer then has the opportunity to recontextualise ideas through further reflection. This serves to reinforce the notion that the designer is not ‘owner’ or ‘originator’ of artefacts produced, but an individual who actively reflects upon and contextualises the knowledge of others in order to realise artefacts on their behalf. This also demonstrates that reflection is intrinsic to the creation of valid and applicable design for any community, as their ideas are assimilated into new artefacts.

Within the model of community centred design presented above, encounters with members of various communities can occur within both structured and unstructured frameworks. For example, a meeting at an institution may have a set duration and agenda, and a known number of familiar participants. A meeting out in the community may be unexpected, informal, of an unknown duration and with an unfamiliar person. For the designer and therefore the project, both of these meetings may be of equal importance and could play a critical role in the development of the project. Both meetings rely on the designer’s ability to reflect in and on action during and after the meeting in order to best assimilate new knowledge and contextualise existing knowledge and therefore adapt and modify designs appropriately.

It is also important to consider how the role that reflection plays can change over the duration of a project, and therefore the significance of the start and finish points. For example, Project Spectrum took place over a three year period, at the outset of which I had only my existing framework of experience upon which to base my reflections on the new knowledge and ideas I was receiving and therefore the designs I was tasked with producing. In order to develop a new framework of knowledge, I embarked upon a process of action research alongside my reviews of the existing literature and artefacts. During this process the emphasis was very much on reflecting in action and immediately on that action in order to organise new knowledge and begin to formulate suggestions for new designs. As the project continued and I became more familiar with the community and the themes of the project, I found I could reflect more successfully on my reflections in action, having developed a wider context for the project. I would however argue that it was only after the completion and realisation of the designs that a considered reflection on action and reflection on reflection in action could take place. My assertion is therefore that within the iterative process of action research, design, and testing, lies a symbiotic relationship between the design process and the reflective process. The reflective process nurtures the creation of new and valid designs. The realisation of these designs provides a retrospective context for the reflective process, which is itself realised through an active investigation of the project such as this research.

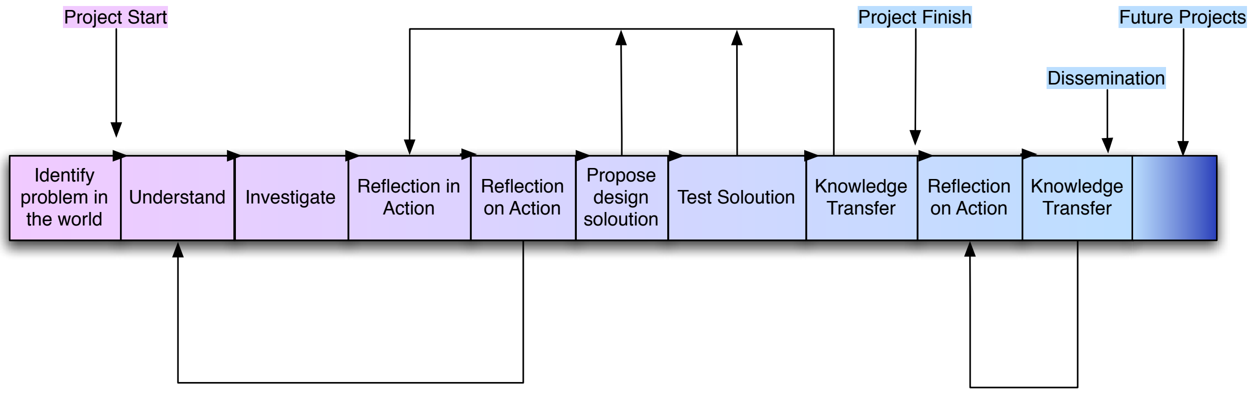

Figure 4.3 - The Reflective Process within community centred design

Figure 4.3 illustrates this model for reflective practice, and shows the part that reflection plays in the iterative design cycle. This begins even before the start of a project with reflection on an existing problem leading to the initiation of an investigation, and reflection on this initial problem forming the start of the design cycle. Further reflection takes place after the cycle of design and design testing has been completed. In the case of Project Spectrum, this further reflection on action following the end of the project has led to the writing of this thesis and also to the development of further work in this field, as well as to the dissemination of the Project's findings to the wider community, through publications, an online resource and a digital archive. Each of these in turn has led to further discussion and therefore reflection and knowledge transference.

The complete model for community centred design emerging from this research and as applied to Project Spectrum is now presented, and shows how user centred design, action research and reflective practice become integrated in a process that takes place over a period of time, and involves an iterative engagement with each of its aspects.

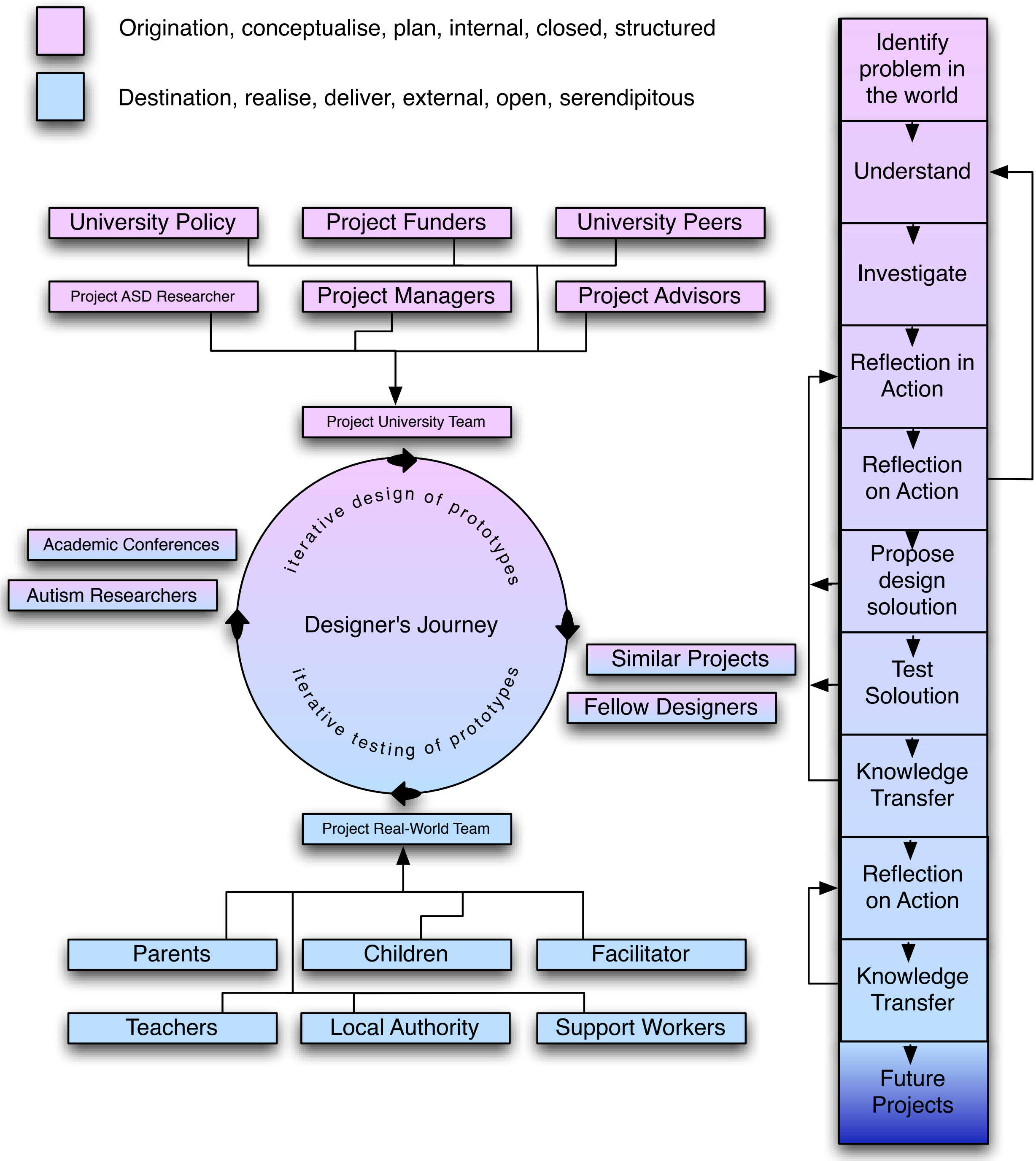

Figure 4.4 - Community centred design model as applied to Project Spectrum

<u>Action research diary</u>

Throughout Project Spectrum I kept a design diary of the significant events that informed the design process. This formed part of my reflective process, and has subsequently allowed me to gain greater understanding of the journey I undertook leading to the emergence of the above models (4.2, 4.3, 4.4). During the project, the information from the meetings informed much of my immediate reflection in action and therefore the designs for the artefacts.

The following list describe a series of encounters that took place during the action research phase of the research, which subsequently guided the design process. They include meetings, semi-structured interviews, site visits and informal observation sessions all of which played a part toward my integration into the community and the development of my knowledge in the field. This is followed by descriptions of the prototype testing that iteratively took place alongside the encounters. Together these give a more detailed view of the action research and how this informed the design process discussed above.

Although my research took place with the support and ethical clearance of the University project team, most of it was undertaken alone and therefore is more representative of my own subjective approaches and responses to the ideas gathered in the field. This includes taking a more informal approach to gathering knowledge amongst the community in order that participants should be relaxed in discussion and not feel intimidated by the process. In this way members of the community could become central to the project, rather than feel like external resources to an academic project. I did not therefore feel comfortable using formal questionnaires or having a set series of questions to ask people, but rather engaged with them at a personal level and allowed them to tell me about their experiences and their responses to the ideas I expressed to them about Project Spectrum. This led to me obtaining tacit knowledge from the community which might otherwise have been lost amongst more formal questioning. In addition it led to a greater level of acceptance amongst the community, which in turn made it easier for me to work with them as co informants of the project and to extend the network of the community. For example one mother whose son took part in prototype testing, then invited me to met with teachers at his school and to present the work to them. Another introduced me to members of the local authority who worked with her and her son. This may not have been possible without a more familiar and informal approach. This ability to move between and communicate with different communities is an essential skill within the community centred design model, and represented within the ‘designer’s journey’.

Similarly when observing children participate either during their usual activities or during prototype testing, I did not enforce any strict criteria to my observations, but rather, with the guidance of teachers, parents and carers, observed the behaviors that occurred and interpreted these into the user requirements and subsequent designs. Whilst this method may lead to very personal interpretations of the user requirements, it also opens up design possibilities beyond any predetermined expectations, and allows for design to go in unexpected directions based on the responses of the community. If the designer is open and adaptable in their approach and can create artefacts that mirror the requirements of the community, then more appropriate and sustainable work will be produced.

i.) <u>Interview with a mother living and working with children on the autistic spectrum</u>

This began with a semi structured interview with a co ordinator from the Autism Specialist Support Unit, UK. She is the mother of three boys on the autistic spectrum, one of whom joined in the interview. The interview took place at the family home and yielded the following key findings:

Table 4.2 - Preferences of three brothers on the autistic spectrum

Likes	Computers and computer games
	Spinning and watching things spin
	The feel of BluTack
	Dinosaurs
	The colour green
	Neutral sensory environment to concentrate on tasks
	Soft play environments
	Music for calming down and blocking out other sensory stimuli
Dislike	Interacting with others
	Sharing experiences
	Losing at games

	Physical activity like sports
	Disorganised noise
Would like	Movement as a way of controlling computers
	Computer games that involve crossing the midline
	Experiences that allow for individual sensory sensitivities
	Abstract games where purpose is not a barrier
	Something tactile to fiddle with
	Something familiar within new environments
	Access to inclusive sensory environments

As already mentioned, the findings from this interview demonstrated that the preferences suggested by Jackson's findings were trends, and that the sensory requirements of the children were not always consistent. It also reinforced her findings on preferences for sensory activities that included movement and spinning and the importance of colour, sound and other sensory stimuli within the day to day experience of the child. This interview illustrated the preference for computer based activities and games amongst the boys in this family, similar to Jackson's observation of two boys using a games console. Further to this, the need for some sort of sensory retreat was mentioned, and methods of using certain sensory stimulation to block out or reduce others. This would become a common area of discussion when later researching in schools, in which an existing sensory room or classroom would be used for this purpose. Some schools felt limited in not having a designated low arousal space, specifically for children to 'chill out' in. The need for such a space was embedded into the user requirements for Project Spectrum and realised in the design of the environment.

ii.) <u>Interview with Dr Diana Pauli</u>

As part of my field research I had opportunity to meet with Dr Diana Pauli and interview her on the findings of her 'Colour Impact' project. Pauli worked with pupils on the autistic spectrum to discover what effect different coloured lighting had on their mood and behaviour. This was of interest as we expected to be projecting different coloured light via the interactive modules, and were also discussing the use of coloured lighting to illuminate the environment. Her research could also shed some light on the findings so far regarding preferences for particular colours.

During my visit I observed a session of Pauli working with one of the pupils. The environment was a neutral grey coloured room with soft play cushioning covering the walls and no additional props. Overlooking this space was a lighting room from which a member of staff controlled the colour and brightness of the lights. The lighting was a series of bulbs with red, green and blue gels over them. Pauli worked with one pupil in the space, engaging in an intensive interaction session, which was complimented by the lighting. As the energy levels in their interactions increased the staff member would make the lights brighter and use more red colours in the mix. As energy levels lowered, more blues and greens were used.

Pauli (2004) had found that changing the colour of the lighting had altered the behaviour of children in the environment. Red lighting increased the levels of stimulating behaviours exhibited by the children, such as finger flicking or chair rocking. This behaviour significantly reduced when blue and green lights were used in the room. Pauli had now integrated this use of lighting into her intensive interaction practice in the environment. So far this use of intensive interaction coupled with changes in the colour of lighting had yielded the following findings (Pauli, 2004 and 2006)

•Increased engagement, including improved eye contact and the showing of affection

•Increased willingness to take part in shared movement exercises, whether planned or spontaneously improvised

•Increased ability to take part in games with an understanding of 'rules' such as turn taking and boundaries of behaviour

•Progress in the learning of new words

•Progress in the ability to use imagination in 'pretend' games

- •Progress in the ability to express emotions through gesture and speech
- •Progress in the development of 'acting' skills

Pauli's findings are rather intriguing when considering how colour might be used within future sensory environments for children with an ASD, particularly when seeking to nurture engagement. When I discussed some of the initial ideas behind Project Spectrum she was less convinced on the ability of computers to compliment the engagement process, preferring to use human to human interactions and support these with lighting. This discussion helped to clarify that Project Spectrum would not be about replacing person to person interaction with the child with computer interaction, but rather about using the different methods of engagement offered by the technology and harnessing the enthusiasm expressed by the children for computer based activities, in order to support social engagement within the environment.

My meeting with Pauli led to a consideration of the participatory role that a facilitator would take in using the PS environment with the child, and the experience and training they would need to support the child's engagement. They would need to have interpersonal skills in working with children with ASD and also be trained in using the environment and the interactive modules. To provide a consistent experience, a child should work with the same facilitator, and the relationship between the two should have time to holistically develop.

iii.) <u>Interview with Dr Chris Creed</u>

During a visit to the MEDIATE installation at the Aspex gallery in Portsmouth, I interviewed the lead designer on the project Dr Chris Creed (see supporting material page 13). Because the MEDIATE project was nearing completion, and because it shared several of the aims of Project Spectrum, I was particularly interested to discuss with him what he felt the successes and limitations of the project were, in order to draw on his experiences and knowledge. This discussion took place before the evaluation of MEDIATE, and therefore we were unable to discuss any findings from that report.

One of Creed's first pieces of advice was not to spend too much time talking, thinking and reading and to get on with making the work. He felt that not enough time had been allowed for this during his project, and that therefore things were not exactly as he would have hoped. One of the results of this was that the environment was quite complicated to setup and rather temperamental during operations. For example he described how if the camera system moved only slightly it could throw out the functioning of the whole environment. Another teething problem was children not being heavy enough to trigger the sensors in the floor. If the build of the environment had been completed earlier then technical problems such as these could have been corrected before the evaluation period.

Managing an international project, in which various teams worked in different countries to deliver various aspects of the environment had been challenging and there had been no one on the project team qualified at the outset to take on this role. The relatively ambitious size of the final environment had also been a challenge, and the team had had difficulty finding space both to build and to deliver the work. This also related to another key criticism of the project, which was that the team had proposed to develop a product that would be portable. Creed appeared adamant that with hindsight he would not have agreed to creating a portable environment, as it was an extra layer of complexity and cost for the project. This influenced the requirements for the portable version of Project Spectrum, that it should require minimal setting up time, be easily transported and setup by one person in a variety of environments. This would allow flexibility for delivery which I consider the purpose of having portable equipment. Creed's observations also influenced the decision to locate the PS environment in a school so that it could be part of the children's everyday experience and easily accessible, rather than a 'novelty' which they would have to visit.

We also discussed how the interactive digital activities offered within the environment were introduced to the children and how their experience developed over time in order to promote and sustain their engagement. During this Creed identified a key distinction in the way this audience is designed for: i.e. the need to design a rewarding experience but not to reward for a predetermined or expected behaviour. Therefore it is not required that the child engage in a specific way, before the environment responds and they are rewarded with a 'new feature' or sensory stimulant; but rather that the experience is allowed to develop alongside the child's engagement. This led to consideration of whether task based activities should be designed that reward a particular response such as eye contact or spinning, or whether more exploratory and open ended activities should be designed that could allow for such responses, but did not require them. Creed's comments helped to shift the focus to the design of modules that promoted engagement on various levels, but that did not always specify a required form of engagement. I began to categorize the modules to be designed as interactive and reactive. The first of these would require the child to interact with them in a specific way in order to achieve a task and progress the module. The others would react to the child no matter whether they consciously or deliberately engaged with the module or not.

Such categorizations for the modules also helped in the consideration of tailorable experiences. Certainly my previous research and prototype testing had revealed the range of abilities and interests amongst children with an ASD. For example when using the early 'balls' module (see supporting AV material p.14), having the balls follow the movement of the child as soon as they entered the space was certainly advantageous in getting their attention and then keeping them playfully engaged as they explored the possibilities of movement, control and response. However for some children, once they understood the mechanism of the engagement this was enough and they wanted a new challenge. As the project continued and more testing was done, it became clear that the level of complexity and interactivity of the module did not necessarily equate with the ability level of the child. Some children who were described as having quite severe autism would tire quickly of a particular module, whilst others would engage for lengthy periods. Some pupils who were expected to be too able for some simple reactive modules, actually chose to engage for long periods of time and clearly enjoyed and benefitted from doing so.

We discussed how the MEDIATE environment might adapt during a session in response to the child's behaviour. Using a software called 'Signature', the environment was able to recognise repetitive behaviour from the child and respond accordingly. It could then modify its responses to their actions, for example increasing activity in a certain area and decreasing it in another. This allowed each child to have a bespoke experience based around the sensory facilities available and to sequence events through their actions.

The use of 'Signature' was similar to Krueger's early work Metaplay (1970), in which the unseen hand of the artist responds spontaneously to the behaviour of his audience, developing an abstract narrative between the two. When planning the design of Project Spectrum, I considered the dynamic relationships that could exist between the child, the computer and another person. Given the difficulties with social engagement revealed in the literature review, it was important that children using PS would not only engage with the computer but also with at least one other person. The sensory media and interactions offered by the computer would provide a starting point for this engagement, and might be a shared experience. This distinguished PS from Mediate, which was designed as a single user experience; an environment that the child entered alone, with the 'signature' software only able to interpret the actions of one person at a time.

Rather than using 'intelligent' software, the Project Spectrum modules would be controlled by a facilitator, who worked in the room with the child. This decision was made firstly as the environment would be a social space in which the facilitator and child could work together. Secondly the project team felt that the facilitator would make more intuitive and sympathetic decisions on progressing the child's experience whilst using the environment than software would be able to. This also removed a layer of complexity from both the design and the delivery of the project, but did reveal a new requirement for a facilitator who would be both sensitive to the children's needs, able to work with them and happy and able to operate the computer equipment.

iv.) <u>Interview with Bruno Martelli and hospital unit teacher</u>

Bruno Martelli was the digital designer of 'The World their World'. I met with him to discuss the commonalities between our projects, the methods he had used to deliver his design work and his thoughts on the use of technology within sensory environments. Martelli employed an iterative design cycle, working with fellow artists and hospital staff to draw up initial ideas and designs for interactive modules, which he would then produce and test with the children. Following this the team would review their observations and he would modify and augment the modules accordingly. As part of this process Martelli worked closely with the lead practitioner from the hospital to develop technology, and in particular a user interface for the modules, that was easy to use during sessions. Whilst his contact was with primary users only rather than the wider community, Martelli described this close working relationship as a huge bonus to the delivery of the project.

The technological setup of 'The World their World' was very influential in the design of Project Spectrum. Similar to the early prototypes for PS, Martelli employed a single camera to pass video data to a computer, which would then process this signal and deliver audio visual responses into the environment through speakers and projector. This was used to composite children into video backgrounds and to produce abstract colour and sound effects in response to their image and movement. Martelli demonstrated how these modules used a dual screen approach. On the computer screen was the interface that the facilitator would use to control the modules, whilst the projection showed what the child would see and engage with. The interface itself was very simple using simple sliders to control the amount of an effect, with a linear menu along the bottom of the screen to allow the facilitator to quickly choose which module they wanted to use during a session. In addition this system only required a single mouse to operate it and if the facilitator was given a wireless mouse, they could stay by the child during sessions. These features would be integrated into the Project Spectrum software as they demonstrated a quick and intuitive way for a facilitator to control the modules with minimum training.

Unlike Project Spectrum these modules did not employ any tracking of the child's image to allow them to trigger specific events on screen, and Martelli and I discussed how this might be achieved whilst maintaining the simplicity of the software. This would later be presented in the Project Spectrum Spots and Cogs modules.

I also had the opportunity to interview a teacher at the unit who was the lead contact at the hospital for this project and the primary user of the environment alongside the children. She had participated in the design process throughout. Of particular interest to me was that she felt children and adults enjoyed the experience of the environment 'together'; rather than it being something that adults did for children, it was a shared activity. Also she commented on how using the screen as a mirror allowed children looking at the screen to observe their proximity to those around them, begin to contextualize themselves within the environment and to play with this by nudging the person next to them etc. These observations implied that there was something inherently social about the environment and that this was drawn out by allowing children and adults to use it together. Whilst the environment had not been primarily targeted at children with social difficulties, following its initial use, they had been identified as users who would be expected to benefit from using the environment and had been invited to begin using it.

v.) Observation of children using Soundbeam

As part of my residency at an autism specialist school which I set up to augment my work on Project Spectrum, I observed several classes using a 'soundbeam' with an artist who had been invited into the school to run the sessions. The 'soundbeam' uses an invisible beam of ultrasound which when broken by the children produces sound from a selection of virtual instruments. By varying their proximity from the sensor the child can control the range of notes produced. This can be achieved using fine or gross movements.

This was a good opportunity to observe how children with ASD engaged with an interactive experience using sensors connected to a digital device. I was interested to see how they responded to the lack of visual cues when using the 'soundbeam'. I also observed how the classroom layouts supported or hindered the delivery of the session and how the artist as facilitator positioned herself within the environment to engage with the pupils.

Amongst the less able pupils the first barrier to engagement for the pupils was having an unfamiliar person (the artist) working with them. Often their teacher or assistant would have to model how to engage with the beam as they would not follow the artist's lead. The more able pupils again worked closely with their teacher, but were more acknowledging of the artist's presence. In each scenario, the artist introduced the equipment and activities to the class, but it was the teachers and support staff who actually led the work around the soundbeam. Without the facilitation of the staff the soundbeam would be ignored.

Because the beam is invisible, most of the less able pupils appeared unaware that their movements caused sounds to occur. Many fixated on the physical sensor device which resembled a microphone and attempted to talk into it and some would touch it with their hands or mouths. They also enjoyed exploring the wires that connected the sensors to the main sound box. Inadvertently their movements would cause a lot of sounds to be produced, but most seemed unaware of the relationship. This may have been further complicated by having the speakers positioned about six feet away from the sensor and the child. Therefore the child would be working on one side of the classroom whilst sounds emanated from another. The more able pupils were aware of the control they had over the sound and enjoyed having control over it. They engaged by standing up and moving around the space and exploring the possibilities, whereas the less able pupils generally remained seated. Using a backing beat with the more able pupils helped boost their confidence in playing with the sounds, and the rhythm helped to keep the session going.

One of the sessions took place in the school hall, during which the artist worked one-to-one with a few pupils in turn. Immediately noticeable when using a larger room without any furniture was that pupils became 'lost' in the space. Also, because the beam from the device disperses over distance, the pupils had less control over the device, and therefore it was harder to demonstrate a cause and effect relationship. Therefore an 'active' area had to be described on the floor using sheets of material. Sitting within the space, the artist worked with the pupils, encouraging them to copy her movements, which would in turn trigger sounds from the machine. Again it was unclear as to whether the children understood that their movements were causing the sound, and several were far more interested in touching and looking at the artist than copying her movements. Several pupils stopped engaging at this stage.

The final session took place in a classroom and alongside the beam, the artist connected several push switches so that pupils could trigger sounds just by pressing the switch. This allowed for group work in which pupils could sequence the sounds produced. The pupils certainly showed a preference for the switches over the beam. One pupil enjoyed using several switches on her own, producing a sequence of sounds. Again pupils engaged independently of the artist.

Throughout the sessions, both more and less able pupils showed significantly little interest in watching their peer group engage with the technology. Those that did engage did so on their own terms with the more able ones enjoying the control they had over the sound.

Figure 4.3 (below) illustrates the various layouts of furniture in the classrooms during the sessions, and the locations of pupils, support workers and the artist and 'soundbeam' equipment. This was of interest when considering how the Project Spectrum environment might be arranged to best support the engagement of pupils with the interactive modules and to support the facilitator working with the child. I observed how the pupils responded to having technology in the classroom and whether this was a distraction for them, and how easy it was to introduce them to this equipment and its capabilities within the classrooms. I also noted how support workers positioned themselves in relation to the pupils, whether they sat opposite, next to or away from pupils. This would be organised according to the pupils needs, with some requiring constant one to one assistance. Others would sit separately from the rest of the class, sometimes having their own desk as a physical barrier between them and others.

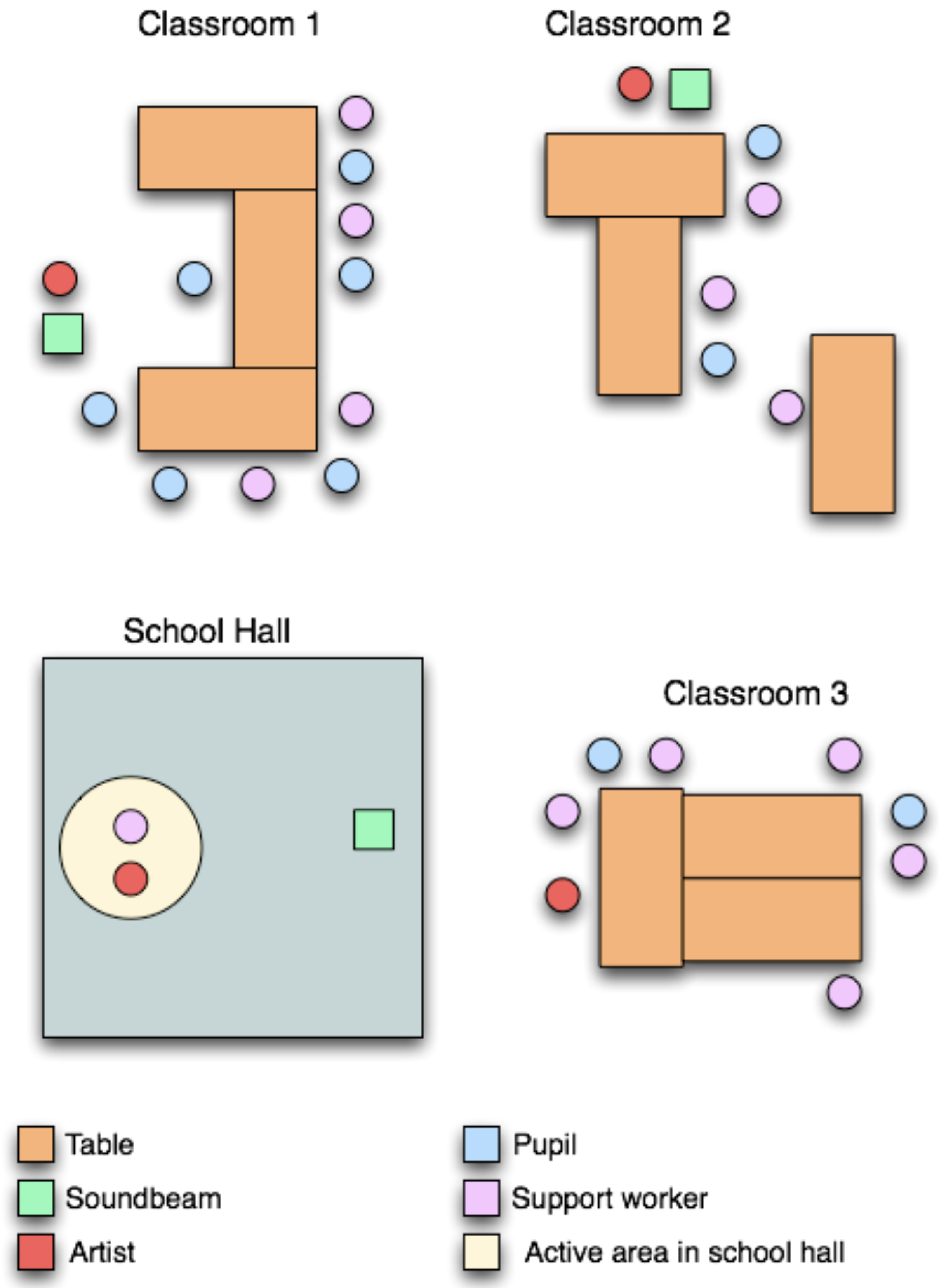

Figure 4.5 - Classroom arrangements when using Soundbeam with pupils

vi.) <u>Visiting a PMLD school with interactive sensory equipment</u>

I visited this school for pupils with profound and multiple learning difficulties to discuss how they had introduced interactive digital media into their sensory environment. Whilst only a small number of the children at the school were affected by ASD, the purpose of my visit was to examine how a school had adopted and integrated interactive media. I interviewed the headmaster and was shown the sensory facilities including the interactive installation that they had procured from the now defunct Millennium Dome.

During a visit to the Millennium Dome in London, staff had noted how engaged some of the pupils became with the kaleidoscopic effect of the Iamascope, and how they enjoyed seeing themselves represented within the virtual ‘glass fragments’ projected on the large screen. Subsequent to the Dome’s closure, the school had taken the initiative of enquiring as to its availability, and the artist had agreed to donate it to the school. It was then installed within their sensory environment, which was also equipped with more familiar sensory equipment such as bubble tubes, coloured lighting and floor cushions.

The head explained that the Iamascope continued to be popular with students and that sessions using it were timetabled into their curriculum. It provided them with an enjoyable sense of control and agency, which he said was based in them being able to see themselves within the imagery. This, and the large scale of the projection, were unlike anything else that the pupils were able to experience at the school.

I was interested to discover about how this piece fitted in with the other sensory equipment in the room, both as a physical presence within the space and as an element of a wider sensory session. It was felt that the Iamascope was used more independently of the other facilities. Some pupils might just use that during a session, whilst others might just use the more traditional facilities. Whilst the Iamascope was in use, it was not appropriate to use the other equipment as it would be distracting, although sometimes background music would be used. (See supporting AV material, p10).

The head teacher explained how both pupils and staff had a particular relationship with the sensory room that was different to the way they approached other classrooms. This was certainly observable in the session. The staff thought of the sensory room as a fundamental part of the pupil's school experience, offering something beyond the mainstream curriculum. For the pupils, visiting the sensory room was a lot of fun and something they looked forward to.

The work at this school demonstrated one model for successfully integrating an interactive digital media installation into an existing school environment. It illustrated how locating the installation in a school provided consistent access to the facility along with the structure and support of the school and staff. It also showed that installing the equipment within an existing sensory environment can lead to distractions for the children when there is a selection of sensory stimulants in the same space. Project Spectrum drew on these findings by locating its delivery in a school and also by creating a bespoke environment dedicated to working with the children and using the interactive digital media modules.

vii.) Reviewing the sensory and ICT facilities at a school for pupils with ASD

As part of a residency at a school for pupils affected by ASD, I reviewed the ICT and sensory facilities available and how they were used by staff and pupils, in order to have a greater understanding of how Project Spectrum might meet requirements in these areas. In particular I was interested in what the purpose of a sensory environment was perceived to be, and how this differed from other rooms in the school, what the perceived role of ICT was, and how it was currently made available to pupils.

Existing sensory room

The school had its own purpose built sensory room, based on the Snoezelen model, using plastic covered cushions and some lighting and tactile equipment. Staff considered the room not to be used appropriately, largely because there was a lack of training and understanding into its purpose and how the facilities might benefit their pupils. Therefore the room was only used occasionally as a space for children to 'chill out' in when they became agitated. Pupils would also use it as a space to retreat to when avoiding lessons or other activities. Some staff felt that allowing them to do this rewarded negative behaviour. Because of the low lighting and soft cushions, pupils would often try to go to sleep there. The school also had a dedicated 'chill out' room which should be used in these circumstances rather than the sensory environment.

There were no existing guidelines on how to use the sensory environment equipment, nor how to structure a session in the room. The location of the environment was not ideal as it was in an interconnecting room, having two entrances and it was rather a narrow rectangle in shape, limiting the amount of space for movement. More space was taken up by seating. The result was a rather cramped environment with little flexibility. The school recognised this and would be replacing the environment. My review and discussion with staff helped them to shape their future strategy towards sensory facilities.

During discussion with pupils two comments were noted that could be embedded into the design of Project Spectrum. The first was that despite enjoying film, one pupil was unable to visit a cinema because of the unsuitability of the environment. A cinema is very large and dark and filled with strangers, an environment in which he could not be comfortable. He also said he couldn't watch television because it made him 'feel sick', and yet was able to watch content on a computer screen. A member of staff suggested this may be because of the refresh rate of the television screen in contrast with the computer monitor. The second was from a boy who wore a baseball cap at all times, saying that the fluorescent lighting in the school classrooms made him 'feel angry' and hurt his eyes. These contextualised my own and Jackson's findings on the sensory preferences of the children, giving examples where certain lighting and computer equipment is preferred and when interacting with strangers or going to a large public space can be difficult. These observations were in turn, embedded into the design for Project Spectrum, and as part of the installation of the environment all fluorescent lighting was removed and replaced with daylight bulbs. A large projection screen was created so that children could use the space as a small, safe and familiar cinema. The projector used in the space had the highest refresh rate available within the project budget.

ICT

Staff agreed that the majority of pupils enjoyed using computer equipment and that they would choose to do this over many other activities. They enjoyed a range of ICT based activities that included playing games on the internet, using bespoke educational software and using office type applications. Pupils in ICT lessons and break times were observed to examine how they engaged with various applications. The facilities provided only allowed pupils to operate the computer using a mouse and keyboard, and content was displayed on a monitor. These were used in expected and some unexpected ways. For example, one pupil using a word processing package would hold down a particular key and enjoy watching the corresponding letter repeat itself across an entire document. He would then reverse this by holding down the delete key. At times he would change the font, size and colour of the letters. He showed a good degree of understanding of how to use the software, but used it to provide himself with repetitive visual stimulation over which he had control.

Aside from learning software packages in ICT lessons and playing games in break times, the pupils did not have access to computer facilities, and in particular did not have the opportunity to develop creativity or sensory experiences around technology. The school recognised this as an area they wished to develop and my residency helped them to initiate thinking in this area.

viii.)Visit to a sensory facility

Because the school's own sensory facilities were lacking, residential pupils were taken after school to a sensory facility. I attended one of these visits to observe how pupils used the various facilities. Being after school, this was recreational time and so the pupils were allowed to engage as much or as little as they wanted. The majority of the pupils opted to sit in a 'white' space with projected lights and vinyl covered cushions. They appeared to find this very relaxing and enjoyed just watching the projected lights. Switches were provided to control the lighting and one child would manipulate this whilst the others watched. There was only a little conversation between the pupils, and they preferred to sit in silence.

In another space a few pupils played more energetically in a ball pit and on a trampoline. Again the pupils did not really engage much with each other, but focussed on their own individual play. They would demand the attention of support staff if they wanted their help with an activity, for example holding their hands on the trampoline so they could bounce higher. Staff would attempt to initiate joint play and would sometimes intervene to calm a pupil who was over excited.

One pupil elected to sit in the 'black space', a dark environment with luminous shapes on the walls and ceilings. When I commented on this, the members of staff who worked with him regularly said that he was happy to stay alone in the space for the whole session and was very much engrossed in his own thoughts and sensory experience. This was a good experience for him and helped him to relax. This reinforced the need for an environment in which children could feel safe and comfortable, and in which they could simply 'chill out' rather than be asked to participate in any specific sensory activities. As a result the Project Spectrum environment could be tailored to produce a dark environment in which children could simply sit or lie on the floor, or chairs or cushions provided and have no visual stimuli, or if desired just a simple coloured pattern projected onto the screen (See supporting AV material p.23).

ix.) Visit to a Sure Start Children's Centre

Sure Start is a government programme to ensure every child gets the best start in life. The centres offer provision for child care and support for parents. I visited a newly built centre firstly to review their sensory environment and secondly to assess it is as a possible delivery venue for Project Spectrum.

The centre housed one sensory room as well as a soft play room complete with ball pit. The sensory room contained a range of equipment including a musical floor that triggered sounds and coloured lights when stepped on, and which could also be triggered by hand using a panel of switches. These facilities were available to any children visiting the centre who might benefit from using the environment.

It was decided not to install Project Spectrum at this Centre primarily because by installing it in a school instead, the environment could be accessed regularly as part of the school day, and so form an everyday part of the school experience. Also the previous visits to schools had revealed that children with ASD should have access to a low sensory environment, one to one supervision and the types of interactive experiences on offer through PS.

x.)Advice from designer Bob Burn

Bob Burn was an advisor to Project Spectrum particularly during the emergence of the design for the environment in which the digital modules would be presented. Burn's LECA project highlighted how the design of bespoke equipment and organisation of the activities that happen around it, can support the learning of children with an ASD.

Burn (2005) argues that the use of colour is not arbitrary within design. For the design of learning environments for children with an ASD he uses two colours to represent personal and shared space. The visual identification of 'one's position' within the environment is supported by giving each child a clearly separated personal space in which to work. This led me to think more on the use of furniture within the Project Spectrum environment, to provide the space with an intuitive geography that delineated specific areas of the space and made their purpose self evident. A child should be able to come into the environment and quickly identify a place to sit and be comfortable before starting a session. The sensory environments studied as part of the state of the art review did not use such a system.

It was also in the remit of Project Spectrum to encourage sharing of activities by children either with a facilitator or another child, whilst still feeling a sense of physical security within a personal space. As part of this sharing children should be able to watch someone else interacting with the digital modules, without feeling any pressure to participate themselves. Prototype testing of PS had revealed how some children needed to watch someone else engaging before they would venture to do so themselves.

Observations during visits to schools of the TEACCH system being used in schools, revealed the need for children to have a space in which they did not have to engage with others or share activities. This would take the form of a workstation that faced a wall. LECA did not offer such a space, and it was felt to be something that should be offered within Project Spectrum, acknowledging that children had a range of requirements and that sometimes sharing and engagement could be supported by periods of privacy and non engagement.

Inspired by LECA, a series of designs were produced for bespoke furniture that might support the delivery of the digital modules within the PS environment. These explored the use of screening to add privacy, and technology embedded within the furniture. However the complexity and cost of producing these was prohibitive if PS was to be affordable and easily replicable. If the environment was to be replicable in schools it would have to be built with readily available furniture, i.e. tables and chairs commonly available in schools, and that these could be organised to demonstrate the principles of privacy and sharing. Although we developed prototypes for soft, curved screens to define different areas within the PS environment, the local authority autism team advised that the use of screening within a classroom that already used blinds over the windows would be considered unethical.

Eliciting further requirements from prototype testing

Prototype modules for Project Spectrum were developed alongside and in response to the iterative gathering of user requirements, and then tested amongst the community. This responsive approach demonstrated to those who provided input to the designs, that their ideas could be implemented into new artefacts, and encouraged them in some cases to become more involved in the project. For example one mother who attended a testing session in which her son took part, later volunteered to assist the team transforming an existing school classroom into the new Project Spectrum environment and then returned with her son to use the environment during the evaluation. Also, by bringing examples of designs to the community, they were able to experience artefacts that they may have been unclear or unsure about had the artefacts merely been described to them during interviews. This meant that further discussions between the community and the designer had a shared point of reference.

Bringing a new acknowledgement of the needs of the children into the community, and offering new technology and designs that might address some of these was in itself a motivator for individuals to get involved in the project and also provided them with a sense of agency and worth. Inviting community members to testing sessions was a good way to publicise this, and therefore raise awareness of the project and its goals. This in turn led to members of the community championing the work, inviting the project into local schools, thereby ensuring its legacy.

Pivotal to development was that the child and not the artefact is placed at the centre of design and evaluation. Therefore testing sessions were tailored as much as possible to meet the requirements of the children, their parents and carers. Because children with ASD are not comfortable with change or with unfamiliar situations, prototype testing took place in environments which they were comfortable in. It was important to minimise any anxiety they might feel about trying a new experience, and to ensure that they and their parents and carers felt safe and at ease with the process. Therefore, whilst the University did offer a usability laboratory in which rigorous controlled testing could be undertaken and recorded, this was not felt to be suitable as this would have upset the children's routine by asking them to travel to the University and to encounter unfamiliar surroundings. In addition the usability laboratory did not offer the space needed for many of the modules to be demonstrated successfully.

It was far more appropriate and convenient for children, carers and myself that testing took place at venues where members of the community already congregated and where there was already an understanding of the needs of the children and the need for environments and technology that might address these. A large amount of testing therefore took place in schools, and until the PS environment had been installed permanently in a school, classrooms and halls were used. This had the added advantage of a large number of staff being available to support and inform the work, which in turn led to new avenues of research opening up. For example, a care assistant at one school saw particular potential in the project and invited members of the local authority autism support unit to support the work. Some schools involved in the testing process also went on to use it as inspiration for the development of their own initiatives and to make funding requests, recognising a potential for the further use of interactive technology with their pupils.

The downside to presenting the modules in a variety of locations was that it was not always possible to achieve the best possible technical setup, which could in turn affect a child's engagement and enjoyment of the experience. For example if other children inadvertently interrupted a session, if a piece of equipment was not functioning correctly, or if ambient lighting meant that visual projections could not easily be seen. These technical issues could take the focus of the experience away from the child. This highlighted the need to give Project Spectrum a permanent home, in which equipment would always be ready for use and there would be a high level of control over environmental factors, so that children could receive a consistent and optimum experience.

Because testing was centred around the engagement of the child, and because their responses could not be predicted, the modules and sessions were tailored in real time to the comfort and enjoyment of the child. This meant that they would vary in length, that different modules than the ones anticipated might be used, and that some children might use more than one module during a session. For example during one testing session a highly verbal boy showed enthusiasm for the modules, was keen to try more and was able to give clear feedback about his experience. In this case the session extended to meet his engagement. In another session, when a child had shown little interest in a module, a teacher had suggested using a different module with them, which stimulated more engagement from them.

By testing in this way, it allowed designs to emerge for the final environment that were sympathetic to the real world everyday needs of the children. For example having experienced the various responses of the children during testing, the evaluation process was designed to allow children to progress through the modules at their own rate, rather than enforcing a schedule upon them. Likewise the environment was designed to provide a flexible space that would provide options for how sessions progressed depending on the child's level of engagement. If the child did not want to engage for long with a module, the layout of the room supported this. If they wanted to engage for an extended period of time and share this experience with another, this was also possible. Despite not providing tight controls over the evaluation of the artefact, this type of participant centred evaluation was in line with user centred ethos of the research, and placed the user experience above the evaluation of the artefact.

What emerged from prototype testing in the community was the need for a child centred low arousal environment, in which the interactive modules would be used. This was supported by the literature (Department for Education and Skills, 2002) provided by the local authority to address the needs of the children; by Jackson's (2009) research into the sensory sensitivities of the children; and by the project team, who recognised that.

Furthermore, discussions with teachers and parents during the action research had revealed that traditional sensory environments were not always suitable for children with ASD, and that a more tailorable low arousal space might be a more appropriate environment in which to engage the children. The attributes of this space might not be confined to one specific 'sensory environment' but rather demonstrate a set of principles that could be applied to a range of spaces within a school or home. Project Spectrum therefore began to consider how these needs could be met within the remit of the project, and how a replicable and affordable environment could be demonstrated that addressed these emerging requirements.

The following diagram illustrates how the iterative design of the Project Spectrum modules continued the research into the requirements of the children, and went on to inform the design of both the modules and the environment produced:

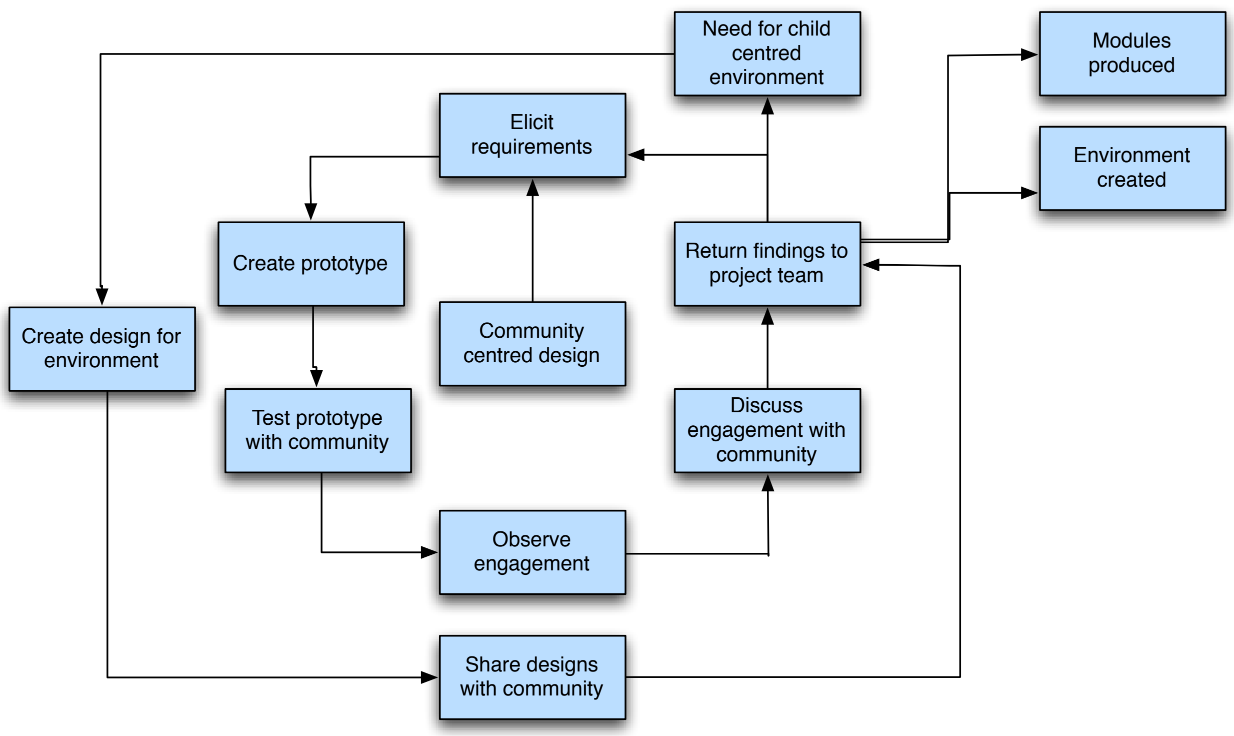

Figure 4.6 - Iterative design of community centred prototypes leading to environment design

A poster (Figure 5.1) which illustrates the findings of this process is included in Chapter 5, and the modules produced are discussed in greater detail in Chapter 6.

i.) Early testing at a school for children with profound and multiple learning difficulties

The first of these opportunities took place early in the project's life cycle at a school for children with profound and multiple learning difficulties (PMLD) who allowed me to use their existing sensory room to test some prototypes. Whilst the pupils at the school were not on the autistic spectrum, this was an opportunity to examine how the PS designs would integrate into the type of snoezelen sensory environment available at many schools. This was a 2hr session, and whilst informative, was not productive enough to warrant repeating.

This was because the pupils had so many existing associations with the types of activity that usually took place in that space, and expectations of the equipment they would normally use, that they were not interested in the new prototypes. The equipment already installed in the space did not allow easy integration of the prototypes into the technical setup of the room, and therefore the modules were not demonstrated at their optimum. In addition, the children did not know me and were happier to engage with staff members who they knew and felt comfortable with.

Following this experience, it became clear that the PS modules could not be delivered in an environment that already contained a range of other sensory apparatus. The observations showed that children associate a type of activity with a given space, and this association can influence their behavior. Therefore PS would need to have its own unique environment in order to encourage particular associations with engagement through the digital modules. This environment should be designed to house the technology delivering the modules so that they could be presented and engaged with at an optimum level.

ii.) Testing at the University

On one occasion the prototype modules were tested at the University with a boy who was visiting with his parent. He had Asperger's syndrome and was able to verbalise his opinions (See supporting AV material p.18-19). The modules tested were two early iterations of the kaleidoscope module, and another which produced sound when he moved either arm up or down, which would later become embedded into the Spots module. He demonstrated a high degree of engagement with the modules, and explained that he found them enjoyable and relaxing.

His feedback was that he liked the control he had over the modules, he liked the colours used in one iteration of the kaleidoscope, and that he was able to see himself in the other. His mother, who observed the session, agreed that he had been very engaged, and that it was good to see him moving in particular ways to generate engagement with the module as he had difficulty with clumsiness and coordination. She asked if the modules might be developed to encourage him to cross the mid line with his arms, something that was difficult for him to do. This idea was also later embedded into the Spots module.

<u>iii.) Testing at a Sure Start Centre</u>

The Sure Start Centre provided an excellent location for members of the local community affected by autism to meet, and several members were invited to attend a testing day. This was supported by the local autism charity. Additional care workers were employed to work with the children when they were not using the modules.

An early prototype of what would become the Stepping module was installed in the main hall of the Centre. This involved children navigating a series of coloured markers on the floor to generate the corresponding colour and a musical tone (See supporting AV material p.20). The space was too big for the installation, but was the only one large enough to accommodate the range of movements encouraged by the module. This meant that there was a lot of empty space around the active space for the installation, into which children might wander. At this time the project did not have its own projection screen, so visual material had to be projected onto the wall. This meant that some of the colour intensity was washed out. These difficulties informed the development of the portable version of the PS environment by highlighting the need for a short throw back projection system that would allow the modules to be used in smaller spaces, displayed with vivid colours, and without the child’s shadow being cast onto the screen.

The children who attended the session, although all on the autistic spectrum, were very different in their behaviour and response to the Stepping prototype. All the children engaged with the prototype and appeared to understand the cause and effect nature of their control over the system's response. Each child explored how they could interact with the installation and appeared to take pleasure from it. Two of the children were very vocal about their engagement, one describing the experience, the other showing signs of excitement. Significantly, one carer commented that the soft sounds used in the prototype perhaps were not the best for engaging all children, and that some more substantial sounds could be tried. This led to a more 'robust' sound being created which was eventually provided as an option within the final spots module alongside the softer sounds. The different ways each child engaged with the system can be seen as a reflection of their individual diagnosis, as shown in the following diagram:

Table 4.3 - Responses of children to Stepping prototype

Child	Diagnosis	Behaviour	Evaluation
A	Asperger's Syndrome	Vocal, exploratory, descriptive	Enjoyed it, but was not very playful
B	ADHD & Autism	Boisterous, vocal & playful	Enjoyed it but might have benefitted from more structure
C	Atypical autism	Exploratory, playful and timid	Really enjoyed it, looked for modelling of how to engage
D	Severe non verbal autism	Exploratory and timid	Was nervous of new experience, yet enjoyed engaging

iv.) Testing at a school for pupils with ASD

As part of my residency at this school I was able to test two of the emerging PS modules, Kaleidoscope and Stepping, with pupils and staff. These were being created in response to the requirement for experiences that encouraged gross motor skills, and that visually engaged the children. The testing took place with the consent of the school and the ethical clearance of the University, and under the observation of staff members who were familiar with the pupils and could assess their engagement with the modules. All the pupils that took part were on the autistic spectrum, however I was not given details of individual diagnoses. These sessions allowed me ascertain whether or not the children were engaged with the experience, and what changes might be made to improve the module.

Stepping

The Stepping module consists of a set of nine differently coloured markers positioned in a grid on the floor. When a user steps on one of these markers a corresponding colour is projected onto the projection screen and a sound is played. The module is tailorable as to the the colours and sounds used.

The module was set up in the school gymnasium, which was a large space with a ceiling high enough to install the camera used for tracking pupils' movement in the space. Using this space was problematic, firstly because the pupils already had associations of the types of activities that took place in the gym, and some were keener to get gym equipment out of the cupboards rather than engage with something new. Secondly the large space meant that visually and acoustically some of the impact of the module was lost. These limitations informed the design of the final PS environment, demonstrating that the room required a clear identity and purpose, which children would come to associate with working the PS modules and facilitator. It would require space large enough to support full body interaction and movement, whilst having clearly identifiable boundaries to stop children from wandering out of the interaction area. In addition the space would have to support a large projection screen allowing life size projection of the children, and have a ceiling high enough to mount an overhead camera to track body movement and a data projector to project images with a minimum amount of shadow cast by the children on the screen.

During the testing session, the module was used in an open ended way to allow me, the teachers and carers to observe how the children engaged with it. I demonstrated the Stepping Stones to each group and they were invited to use it in small groups over the course of the day (See supporting AV material p.20). This process was documented on video and also observed by staff members, some of whom chose to join in with the pupils.

The engagement of the pupils reflected the diversity present in ASD. Some pupils were immediately distracted by other things in the gym and did not engage with the installation, seemingly oblivious to it. Others took some time to engage, being rather timid of a new experience, and preferred to observe for a while before joining in. In response to this, benches were set up for the children to sit on and watch from. This was a successful strategy as pupils who were at first reluctant to engage started to do so having watched for a while. From this the need for an observation point within the PS environment was highlighted and embedded into the requirements. Other pupils immediately engaged with the installation, explored it and having done so, promptly finished their session. For these pupils a more task driven and less open ended activity might have been more appropriate. In response to this, the music teacher used the Stepping Stones module with a group of pupils to choreograph a shared experience in which they cooperated to create a sequence of notes. This group work prompted turn taking and verbal discussion of the work they were doing. This demonstrated to me that the module could be used for group work, given the right facilitation, and reiterated the need for the Project Spectrum environment to include a facilitator who would given structure to sessions by guiding children through the activities, and tailoring them to their needs.

For some pupils the mechanism of the installation was more interesting than the media it produced. Some pupils would ask how it worked and want to see the camera, computer and speakers. Staff explained that this type of fascination was not uncommon and led to a consideration of whether it would be better to hide the technology in the final PS environment, or make it explicit so that if they wanted to, children would have a clear understanding of how it worked. Staff said that they felt the novelty of the equipment would wear off over time, and then pupils might start to engage more with the media. As with the previous testing at the Sure Start centre, some pupils commented that they would prefer different sounds, with some asking for a 'louder' sound. Teachers also discussed how more specific sounds such as transport noises or animal sounds might be used to engage some children. This led to the inclusion of such sounds as options in the final PS modules.

During the testing of the Stepping Stones module, most of the pupils did engage with the installation and staff observing felt it had been an enjoyable and engaging experience. Being their first experience of such interactive media, they felt it was very exciting and well worth pursuing.

Kaleidoscope

The second module to be tested was the Kaleidoscope. Again, this was tested with a range of children with ASD selected by the teachers from the pupils at the school. The Kaleidoscope module was installed in the school hall (approx 7m x 10m), a smaller space than the gym (approx 20m x 12m) as it did not require the same amount of space as the Stepping Stones module. This hall was already equipped with a data projector and screen, and so the module had greater visual presence in the room compared to the Stepping module in the gymnasium.

Unlike the Stepping module, which requires children to step on specific markers on the floor in order to trigger interactions, the Kaleidoscope responds as soon as someone moves into the field of view of the camera used to control it, and does not require any specific type of movement. In order to engage one can experiment with both fine and gross movements, each of which will create a visual response.

Most of the higher ability students were not particularly engaged with the module. Staff felt there were two reasons for this; firstly that the module was very simple only using colours as a visual stimulus; and secondly because they felt inhibited about moving around to engage with the module and that the performative aspect of the module was rather intimidating for them.

The less able pupils tended to engage more with the module and enjoyed the sense of control and the simple visual images. One boy in particular engaged for nearly fifteen minutes, and staff commented that it was remarkable to see him choose to interact with something and to start to play (See supporting AV material p.21). He became thoroughly involved in the activity in front of staff and peers. Staff said that the use of bright colours in the kaleidoscope, whilst simplistic for the more able students, was ideal for engaging the less able ones.

v.) Testing in the Project Spectrum environment

Following the initial prototype testing amongst the community, and having identified the need for a low arousal environment in which to test the digital modules, a bespoke environment was installed in a mainstream primary school. This was local to most of the testing community, and was already used by several children with ASD. The creation of the Project Spectrum environment is discussed in the next chapter (5), and the design of the digital prototypes based on the user requirements is discussed in chapter 6.

Once Project Spectrum had been installed in the primary school, there followed a ‘bedding in’ period during which primary, secondary and tertiary users could become familiar with the space and its role within the school. This period was an opportunity for modules to be tested in situ, ensuring that the technology was working correctly and to solve any immediate technical problems.

The initial users of the environment were myself and the facilitator. She was introduced to the modules and trained in their operation. Once she had an understanding of the modules, we started to develop a procedure for delivering sessions. This was informed by her expertise in working with the children in a school scenario, and her recommendations for integrating the environment into the daily routine of the children. For example creating a symbol for the sessions that could be used in a visual timetable and also on the outside door of the classroom to identify it.

This period also allowed a refinement of the interface for the modules, so that they could be simply and quickly operated. By working with the facilitator, areas that were unclear were identified such as how to ensure that the signal from the camera was accessible to the software, and solutions to these more technical issues were simplified. Often this required creating clear written instructions within the software, and within individual modules.

As one of the children started to use the environment as his educational base at the school, his responses to the environment and various modules were tested prior to the start of the more formal evaluation. This helped to identify any immediate problems with the design and arrangement of the space and of the design and interaction with the modules. For example, it was discovered that it was necessary to clearly mark out the area of the ‘movement space’ in order to assist continued interaction with some of the modules. Also that there was a propensity to sit on the desks to observe the projection screen and to engage with some of the modules rather than to move around as anticipated. This helped to preempt certain behaviors during the evaluation period.

Also during this period we were able to test certain modules that did not feature in the final evaluation. This was because either they were found to be unsuitable or because of technical difficulties. For example a powerful LED lighting system had been acquired that could significantly alter the colour of the environment. This was based on Pauli's research and Jackson's suggestion that different coloured lighting would be desirable. However on testing this it was found that after using the light for a period of time, perception of colour in normal daylight was distorted for about a minute or so afterwards. This might have confused and worried the children. Another module - the interactive wobble board - used a series of tilt switches to measure the angle of a balance board which then controlled one of the visual modules. This was inspired by the use of a balance board by children to help improve their sensory integration (Ayres, 1973). However the technology used was not robust enough for continued testing and did not produce reliable feedback on every occasion, and so was not used in the evaluation.

Chapter 5 - Project Spectrum: Building the environment

Introduction

The previous chapter discussed how a model of community centred design evolved in order to elicit requirements for the creation of interactive digital media for children on the autistic spectrum. As a result of this approach, the project team developed an understanding of how autism affects the life of families (Woodcock and Woolner 2008). This came from the accounts of children, families, teachers and support workers affected by autism, and was recounted both in discussion with myself and in the 'day in the life' diaries provided by fellow researcher (Jackson, 2009). The research revealed that there was a need for regular access to a low arousal sensory environment; that this environment should offer an alternative to traditional Snoezelen environments; that the environment should be tailorable to the individual; and that access to the environment should be structured to meet the requirements of children with an ASD (Woodcock et al. 2006).

The project team therefore decided to install the Project Spectrum environment in a mainstream primary school that championed the inclusion of children on the autistic spectrum. This would provide access to children that was near to home, available to a wide community and that could be integrated into the daily routine of pupils at the school. Furthermore staff and the ASD worker at the school supported the project, would act as facilitators for sessions with the children, and be involved in the evaluation of the project. Local champions of the project who I had worked with during earlier stages of the project helped to introduce the work to the school and its members of staff by presenting it from the perspective of their own practice and research interests. This support was a direct result of the user centred action research approach, and the network of users that had developed during residencies and visits to other schools, practitioners and families. I presented the team's vision for the project to the school head teacher using a poster published at the annual Access and Integration conference at Coventry University. This poster is included on the following page and a higher resolution version is available in the supporting AV material.

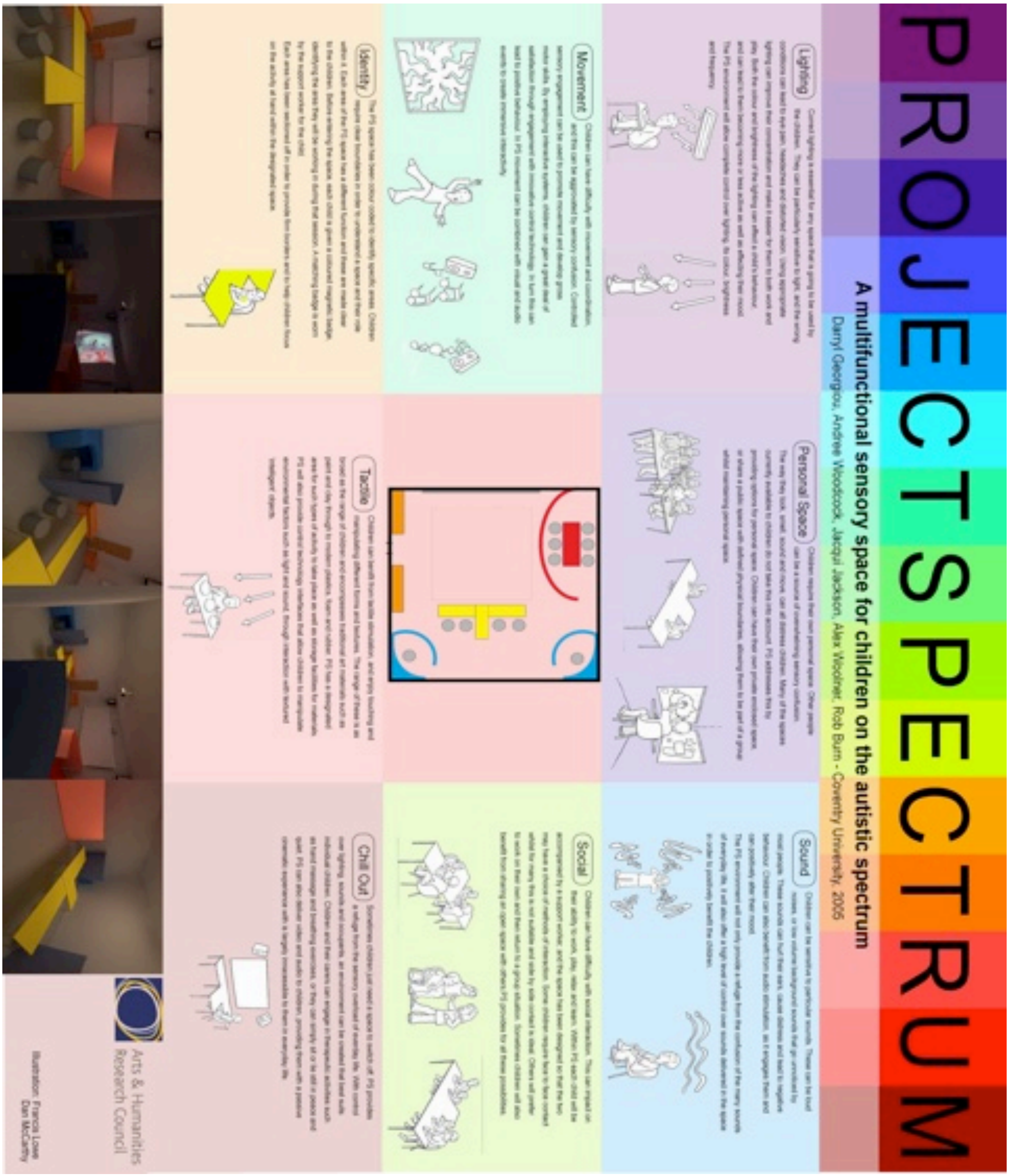

Figure 5.1 - Project Spectrum Poster

Positioning the environment in a school created a new set of requirements (Woodcock and Woolner, 2008), such as the need to use technology that was readily available and affordable, rather than developing expensive bespoke solutions and the need to adhere to school policy and practice. By appropriating existing technology, the facilitator would be able to operate familiar equipment such as a PC and a digital video camera, thus reducing the learning overheads. This model followed the success of previous installations (Greenland et al. 2004) designed to provide interactive computer vision systems for adults to use with children with special needs. Using readily available standard equipment means that the installation is easily replicable and affordable. Building on the review of existing work in the field and the prototype technologies developed in the action research phase, a system that used one desktop computer connected to video cameras, a microphone, data projector, speakers and lighting system was developed. Alongside this software was created, consisting of the modules to be used during sessions with children.

Transforming the existing classroom

Figure 5.2 - The classroom before being converted

1. Figure 5.2 shows the classroom used for Project Spectrum before the installation. The classroom was previously used to teach up to twenty pupils and contained an interactive whiteboard as well as a blackboard, neither of which were required for PS. The first stage in the creation of the new environment was to remove the visual distractions from the existing classroom. This involved stripping, plastering and redecorating the walls. The room was painted white to allow the ambient colour of the room to be set using the LED lighting system. Woodcock et al (2005) had found that although there were trends in colour preference for an environment for children with an ASD, it was important that this was tailorable rather than fixed. Pauli and Smart (2002) observed that the colour of lighting had an effect on the behaviour of children with an ASD.

2. Following this, the existing carpet was removed and replaced with hypo allergenic marmoleum flooring with a neutral grey / white colour. This material is hard wearing, easy to clean, and suitable for children to stand and sit directly on. The

colour chosen was the closest match to the rest of the room and is shown in figure 5.3.

Figure 5.3 - Installing the new floor

3. The windows were covered over with white ‘black out’ blinds (Figure 5.4) to stop daylight from entering the classroom and also to provide privacy from the playground. Both teachers and pupils had recounted how activity outside, other people and weather conditions can be a great distraction when trying to engage children in the classroom, as could sunshine pooling on the walls, ceiling or other surfaces in the classroom. The blinds also ensured that daylight did not wash out images on the projection screen.

Figure 5.4 - White blackout blinds

4. The existing fluorescent ‘strip’ lighting was removed and replaced with a series of daylight bulbs. Fluorescent lights are known to flicker and some children with an ASD are sensitive to this. Conversations with pupils with ASD had revealed that this flickering could disturb them and one boy revealed that they gave him a headache and made him angry. Daylight bulbs do not flicker and were suggested by Jackson as a good alternative. These were installed on a set of dimmer switches to give greater control over lighting levels. An uplighter was provided in each corner to give additional light sources.

5. A controllable LED light was also installed. This could be tailored via the computer software to provide many different shades of coloured light. This was installed in response to the findings of Pauli and Smart (2002) and previous Project Spectrum research (Woodcock et al. 2005).

6. A tailor made large projection screen (Figure 5.5) was constructed, which provided an essential 1:1 scale projected image. This followed the practice of Drago et al. (2003) of using professional projection screen material padded out with 2 inch thick foam, providing an excellent projection surface and ensuring that should a child

run into the screen they would not be hurt. The screen covered most of the front wall of the classroom, providing a focal point for the interactive work. To compliment the screen, a data projector was installed onto the ceiling of the classroom. This was specified to have the correct throw and brightness for the environment and also to have the lowest possible noise level within this category.

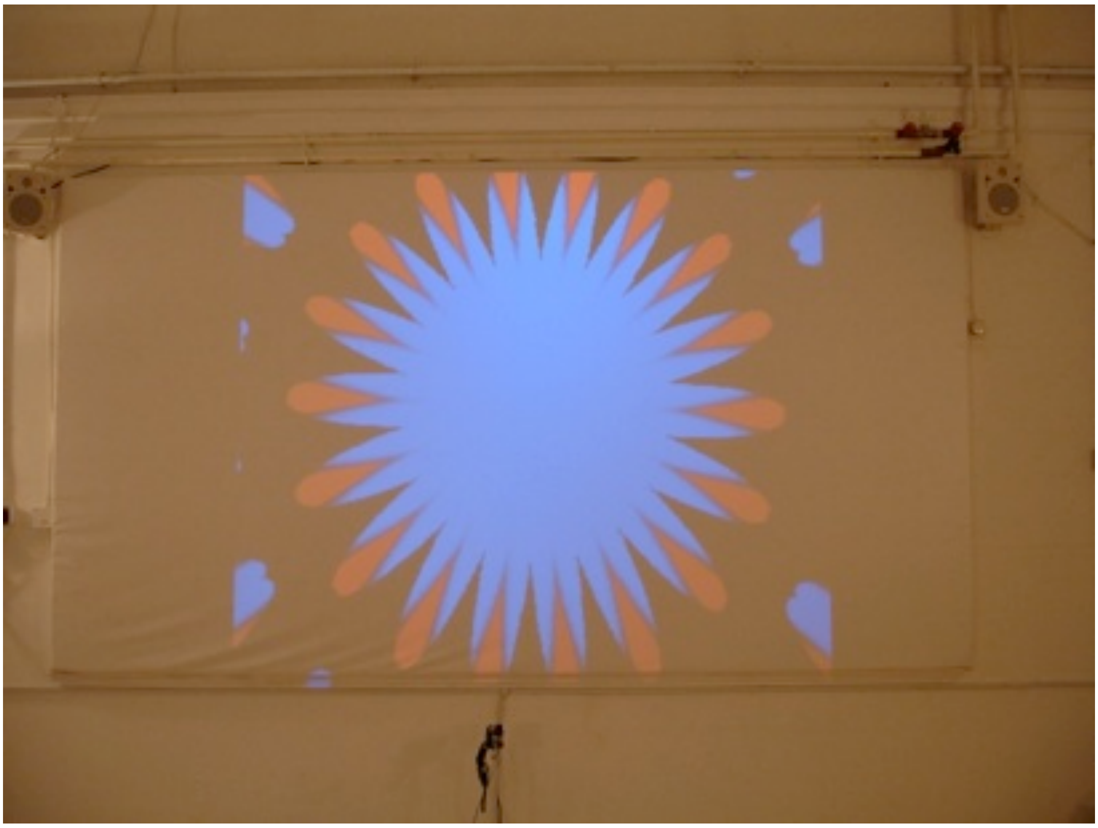

Figure 5.5 - The bespoke projection screen

7. Two digital video cameras were installed in the classroom. At the front of the classroom a mini colour DV camera was positioned below the screen onto a flexible goose neck, allowing for adjustment of height and angle. This camera filmed the children and put their image into the interactive software. It was also used to record sessions for evaluation. A black and white cc-tv camera was installed into the ceiling, which was used to track the position of the child whilst they interacted in the 'movement space'. This information was passed back to the computer for use in some of the interactive modules.

8. Furniture and a rectangle marked on the floor were used to delineate the environment into three distinct areas. At the front was the 'Movement Space' (Figure 5.6), an open space for moving around in front of the projection screen and engaging

with interactive modules. A black rectangle on the floor clearly marked the area in which the computer could see the children via the cameras, and also discouraged children from getting too close to the projection screen. One common occurrence during user testing and observations was for children to get close to the screen and then to look back up at the projector, enjoying the sensation of the light directly hitting their eye. This was not regarded as appropriate by facilitators. Positioning the projector as high as possible and preventing the children from getting too close to the screen, made it harder for them to do this.

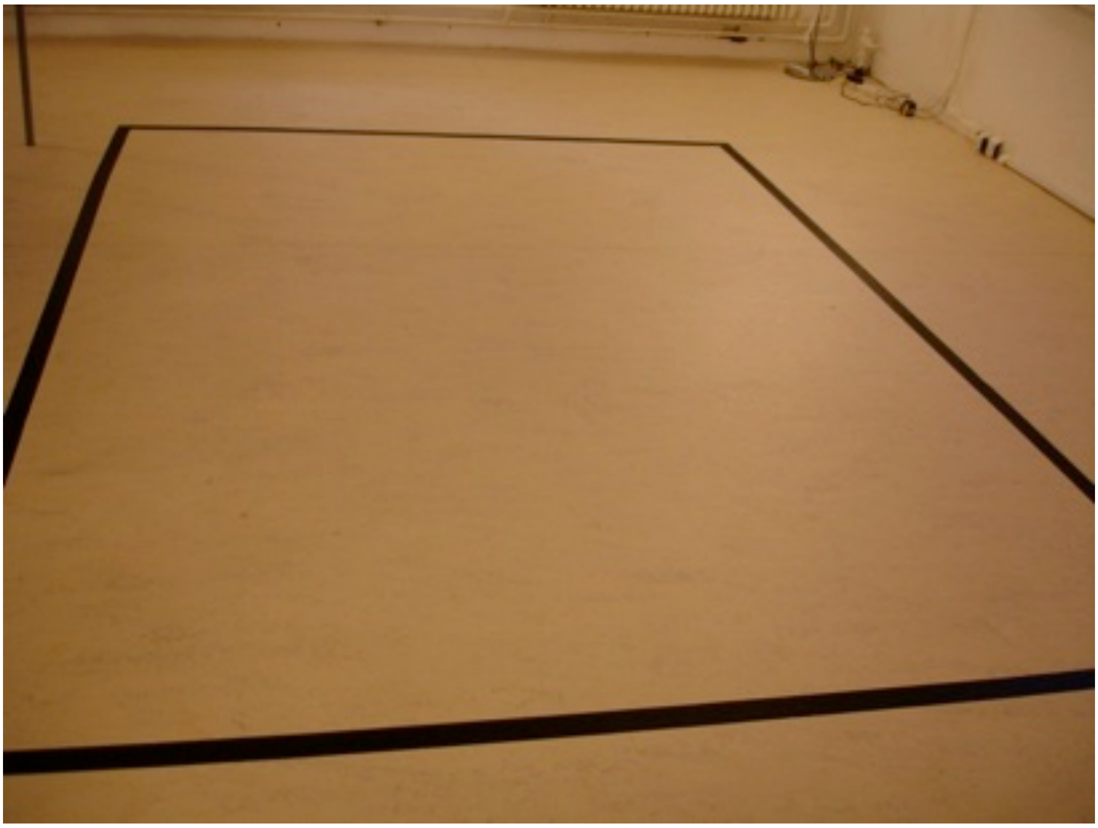

Figure 5.6 - The movement area

The central third of the classroom was designated as the 'Shared Space' and was clearly marked by a T shape of three tables. This acted both as an observation area for the 'Movement Space' and also as a space for children to work with the facilitator. Having created a series of designs for furniture the project team chose (rather than to create bespoke furniture) to use already available school items. This not only saved costs, but also illustrated how a school could provide for pupils with an ASD without having to make a great financial commitment or invest in specialist equipment (Woodcock et al. 2008).

The rear section of the classroom was identified as the ‘Private Space’, shown in Figure 5.7. Here the child could work or rest alone. In one corner, inspired by the TEACCH approach (Siegel, 2007 p.361), was a workstation that faces the wall.

Figure 5.7 - The private work space

It allowed the child to work or rest without any visual distractions in their line of sight. The final manifestation of this space was not how the project team had originally envisaged it to be, and designs had been drawn up to create a curved screen that would partially surround the workstation, offering increased privacy to the child and preventing others being able to see them when they were sitting down, unless looking directly over the screen. However the use of any screen was thought to be unethical by the local authority autism unit, particularly if being used in a room with only one child and one facilitator and which already had blinds over the windows.

In the other corner there was a rocking chair to relax on (Figure 5.8) and which is thought to promote task engagement and focus (NEA, 2006) through vestibular stimulation. This was accompanied by large cushions and a carpet, acknowledging the need for relaxing non digital experiences for the children (Woodcock et al. 2006).

Figure 5.8 - The relaxation area

9. The facilitator and I collaborated to create a series of images based on PECS (picture exchange communication system) (Bondy and Frost, 1994). These were used to label specific areas of the environment including the exterior of the door and the shared and private spaces. A PECS image was developed for the ‘sensory classroom’ (Figure 5.9) and each child involved in the project had one of these to place on their timetable so that sessions would be expected and integrated into their routine.

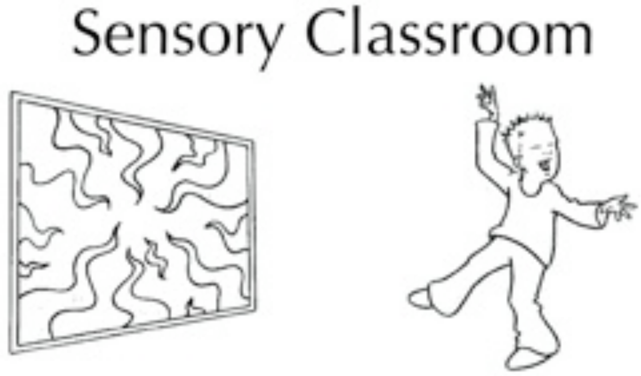

Figure 5.9 - Bespoke PECS symbol

These were brought by the child to each session and put into a folder attached to the door to indicate that the session had begun. When the session finished the child removed the PECS and returned with it to their classroom to place it onto their timetable for the next session. During the sessions PECS would be used to assist the children in choosing which interactive activity they wanted to participate in using specifically developed images. PECS were also used to assist in the evaluation of sessions.

For the purpose of the project evaluation children participated in half hour sessions. During the first they worked with the facilitator in the shared space on an activity such as sharing or turn taking using tangible equipment such as toy animals, and for the second half they worked with the interactive modules to develop engagement.

The following table (6.1) summarises the aims of the Project Spectrum environment and how they were fullfilled:

Table 5.1 - Summary of aims and objectives of Project Spectrum environment

Aim	Fullfilled by:
To make the environment accessible to, and part of local community To provide experienced and familiar support from staff To provide children with a consistent and structured experience, timetabled into their day	Locate environment in mainstream school which caters for children on the autistic spectrum Timetable a regular half hour session into the child's day in which they use the environment
To give the environment and the modules a clear identity within the child's everyday experience	Create bespoke visual symbols for the environment and each of the modules Timetable a set period of half an hour into the child's day in which they use the environment
To provide children and the facilitator with a flexible range of ways to use the environment depending on the child's requirements.	Create four distinct areas within the environment - movement, sharing, private and relaxation
To minimise cost of setup, reducing barrier to entry and increasing repliclability	Use readily available technology and furniture within the environment

Aim	Fullfilled by:
To create a low arousal environment in which children can focus on working with the facilitator and engaging with the modules To avoid overwhelming children with visual information	Clear walls and surfaces of visual distractions
To allow the facilitator to modify the colour of the room using lighting. To match the colour of the room to the child’s preference	Have white walls, ceiling and flooring.
To provide a hardwearing surface suitable for moving and sitting on, and supporting everyday classroom furniture.	Use hypo allergenic marmoleum flooring
To remove the distractions of natural light coming into the environment. To block out any activity taking place outside	Hang black out blinds over windows
To avoid disturbing children sensitive to flickering lights To provide greater control over the intensity of lighting	Removing fluorescent lighting and replacing them with dimmer controlled daylight bulbs
To be able to alter the colour of the environment according to he child’s preference. Having greater control over tone and intensity of colour than when using coloured gels To provide lighting that remains cool and is therefore safer and does not affect the ambient temperature of the environment	Providing a controllable LED lighting system
To accentuate the visual element of the modules by providing a life size reflection of the child, and large imagery. To ensure safety of the child should they want to make contact with the screen.	Providing a large scale projection screen, padded with foam
To have the minimum background noise when using the environment	Use of a low noise emitting data projector

Aim	Fullfilled by:
To be able to monitor and analyse the child's interactions in the movement space and have the modules respond accordingly To allow the children to engage with the modules without the encumberment of any physical interface. To create modules that encourage children to move around, developing gross motor skills and coordination.	Employing two digital video cameras for front on and overhead video tracking

Presenting the modules

A series of interactive modules were created for use within the Project Spectrum environment (See supporting AV material p.26-30) and are discussed in greater detail in Chapter 6. These were designed in response to the requirements of children on the autistic spectrum in order to nurture their engagement. Primarily engagement would be stimulated visually as this had been identified by Jackson (2009) as a strong motivator for the children. Her research also revealed that the children had a preference for projected lights and sound and light equipment. Visual content was delivered through a digital data projector onto the bespoke projection screen. This stimulating focal point was supported by the layout of the classroom and its low arousal design and colour scheme.

Each module was designed to engage the child with an event that took their actions as a starting point and translated them into a sensory experience, making them the initiator of the interaction. This could be presented to them both visually and as sound, and offered immediate feedback. A loop of interaction was created as the system responded to the child's actions and the child in return responded to this new event. A dialogue consisting of movement, visuals and sounds would emerge as the child explored the nature of the sensory experience being provided. It was hoped that this would promote a sense of agency in the child as they initiated new experiences through their sensory engagement, which would in turn lead to increased interactive, communicative and imaginative behaviour.

The modules were presented in a sequence suggested by the facilitator. The complexity of the interaction with the module increased as one progressed through this sequence, and each built on the design of the previous one, so that the child could develop an understanding of all the modules and their own agency within them. However the facilitator was able to choose any of the modules at any time, and could easily miss one if appropriate. This could make the evaluation of individual modules difficult should the child or facilitator choose not to use a particular one, but did ensure that sessions were more easily tailorable to meeting the child's requirements.

In response to the identified need for social engagement and structured and individually tailored sessions, a facilitator worked with children to guide the work that took place when using the PS environment. This included the selection and tailoring of the modules, as well as introductory and finishing sessions in which the child's mood and level of engagement could be ascertained. While working with the modules, the facilitator was able to address particular difficulties the child might have as part of the session, such as turn taking, facial expressions and verbal communication.

The software was designed to be easy to setup and quick to function, whilst providing tailorability for the facilitator. It was recommended that the facilitator set up the module before a session, and that this should not take more than a couple of minutes. This was important as use of the environment had to fit smoothly into the busy working day of the school and the facilitator and because keeping children waiting for sessions would upset their routine and therefore be potentially detrimental to their experience and therefore engagement levels.

By simply pressing the power button on the computer, the software launched and presented the 'start' screen. From this the facilitator could diagnose the system and ensure all the attached devices are running properly. Having done this the required module could be selected from a menu and tailored using a system of sliders to suit the preferences/abilities of the child. Each module had its own tailoring screen with a default 'ready to go' setup, which would allow the facilitator to set parameters such as colour, size and sound. The facilitator was provided with a wireless mouse should they wish to reconfigure any of the modules during the session without having to leave the child's side.

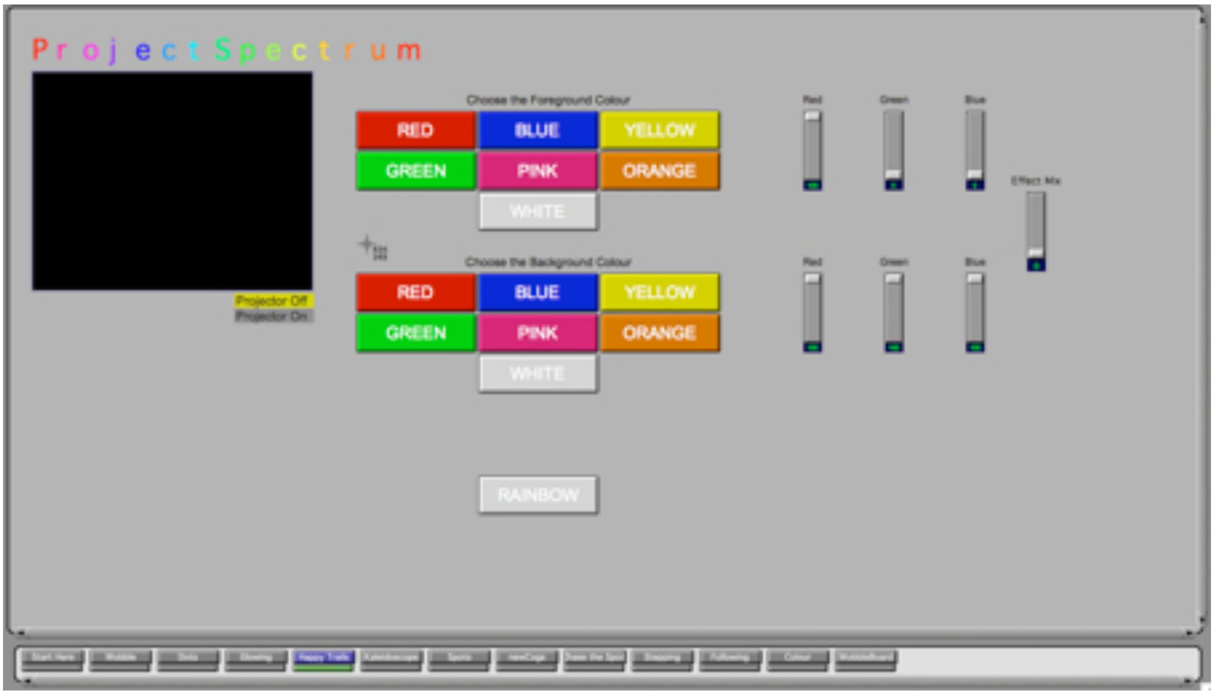

Figure 5.10 - Screenshot of software user interface

Module tailorability was discovered as a requirement gathered by Jackson and presented in the literature on the triad of impairments. For example Jackson highlighted a strong response to colour amongst children with an ASD. However, although children are sensitive to colour, their preferences and reactions to colours are different. Therefore all the modules involving colour allow the facilitator (based on their knowledge of the child) to decide which colour(s) to use.

Shapes such as circles and cogs, and the ability for the system to mirror the image of the child, were all included in response to Jackson's discovered requirements which highlighted these as the visual elements that were important to the children in her survey. The nature and complexity of the interaction with these elements was tailorable by the facilitator, in recognition that autism is a spectrum disorder and that different experiences are required for different children, as brought out by Jackson's research and the subsequent community research.

Such tailorability through the use of computer controlled systems is a recent and important technological innovation. It has important implications for the future design of multimedia experience to meet the individual needs of children and could applied more widely in the context of mainstream education, providing learning resources for a wide range of children. However, this first requires an in depth understanding of that child – something which is not usually possible in large, mainstream classes.

Chapter 6 - Project Spectrum Prototypes and Modules

Introduction

The previous chapter discussed the creation of a low arousal sensory classroom within a mainstream, into which technology was installed for the delivery of the Project Spectrum interactive digital modules. This chapter dicusses the creation of the modules to be used within the environment. The modules were designed to meet the remit of the project to create interactive digital media for children with ASD; to meet the elicited requirements of the children and their carers; and to be integrated into the sensory environment using the installed technology for their delivery. This process meets one of the main objectives of this research.

The development of the digital modules involved the iterative design of prototype modules from the outset of the research. A pre existing module, 'chase the balls' (see supporting AV material p.16-17) was used at the start of the research to initiate testing amongst the community, but as the research continued new prototypes were developed in response to requirements. The pre existing module was used with children and demonstrated to other members of the community to illustrate the type of engagement that was possible with computers using a camera system to control interaction rather than a keyboard or mouse, and the difference in using larger projection to view the computer's output rather than a smaller monitor. This module was chosen as it already matched some of the criteria emerging from Jackson's (2009) review of requirements for the children. It used circular shapes, was very colorful and allowed the user to control it with gross or fine motor skills. Additionally it had already proved popular with young people when used during previous sessions with mainstream and SEN schools.

Observing children using the 'chase the balls' module during prototype testing sessions revealed that they would move their body or parts of their body left, right, up or down to control the movement of the balls on the screen. Moving toward or away from the screen would move the balls up or down as they became bigger or smaller in the eye of the camera. As their movement focussed on controlling the balls, it did not relate to the space they were moving in. To me this showed a level of absorption in the task and especially the visual elements.

The role of the facilitator

The work of the Aurora projects (Robins et al. 2004) revealed the importance of having a human facilitator to communicate with a child with ASD alongside the technology provided, arguing that “human contact (the experimenter) provides meaning and significance to otherwise mechanical interactions (the robot)”. Likewise having engaged with the community to develop the prototype modules, Project Spectrum had benefitted from having carers present during testing who could support the children during sessions, and evaluate their responses for the designer. This had revealed the value of having a suitably experienced individual present during sessions with the children. This was taken into the final environment by employing a facilitator for sessions who would work with the children to provide “meaning and significance” to their experience and also to help in the evaluation of their responses. In particular the role of the facilitator was to develop the person to person engagement of the child, thus meeting one of the key aims of the project and also integrate the experiences into the rest of the school activities.

The use of the modules and the sensory classroom was reliant on the facilitator who would work with each child and be a constant and familiar face throughout the evaluation. Over this period they could develop a strong rapport with the children without which strong levels of engagement shown by the children may not have emerged.

The facilitator is an integral part of the Project Spectrum environment, and their role is multi faceted. Primarily they are responsible for nurturing the engagement of the children, using the facilities provided in the environment. This means they have knowledge both of the individual needs of the children, and how to use aspects of the environment to meet these needs. Initially they are responsible for introducing the child to the environment and to themselves, and making them feel comfortable in a new space with a new person. During Project Spectrum this introduction was made alongside an adult with whom the child was already familiar.

Once the child is comfortable with the environment, the facilitator can then introduce the child to the first module, the ‘Mirror’ module and gauge their response to it, evaluating whether the experience is appropriate. Firstly they model the module for the child, allowing the child to stay seated and watch them use the module, before inviting them to step up and engage themselves. This process is tailored to individual children, and the facilitator will always proceed in a manner that suits the child's needs. For example if a child is reluctant to engage with a module, the facilitator can decide on the best course of action, possibly allowing the child to watch for longer until they feel comfortable, possibly asking if the child would like to engage alongside the facilitator, or possibly moving to another activity that does not involve the modules.

The facilitator's role also includes tailoring the modules to the requirements of the children. This requires them to know how to operate the equipment, and during Project Spectrum the facilitator was trained in preparation to using the equipment with children.

Software and Hardware

Project Spectrum used readily available hardware such as an Apple Imac computer, an off the shelf data projector and off the shelf low end digital video cameras. This was because the design was created to be easily replicable, and within the limited budget of schools and centres that might employ it. By using readily available equipment, schools could easily purchase and maintain equipment which they may already be familiar with from use in other areas. This meant that less specialised knowledge was needed to use the equipment, and more members of staff and therefore pupils would have access to it.

The software was created using a package called Isadora (Coniglio 2004) which allows authors to create bespoke applications to manipulate audio and video in real time from both pre recorded and live sources. Whilst the software originated for use with dancers during live performances, it lends itself well to creating applications for children that use cameras as motion tracking devices (Drago 2003, 2005, and igloo 2006). It was also chosen for the ease with which simple user interfaces could be created, meeting the requirements of the facilitator and any other members of the community who might use the software with a child. A screenshot of the user interface is shown in Chapter 6 (Figure 6.10). By using a readily available and well documented piece of software, this allows other designers to more easily continue the work started with Project Spectrum, by building on the existing platform.

Whilst using a package such as Isadora did facilitate the creation of modules suitable for Project Spectrum, this also presented limitations. For example the software is not sophisticated enough to distinguish individual people through camera tracking, only recognising that movement has occurred within the image. Therefore it was not possible to create multi user experiences where the computer would recognise more than one person through the camera and respond accordingly to distinct interactions. However the budget and time constraints of the project meant that such sophistication could not be developed as this would have involved a significant amount of resources spent in the creation of new software, and this was not the remit of the project. For the 'Vocalising' module, an additional piece of software called 'Pure Data' (http://puredata.info/) was used alongside Isadora, to accurately measure the volume and pitch of the child's voice.

Mapping the requirements into the Project Spectrum environment and modules

The initial remit of Project Spectrum was to create a series of interactive digital modules and suitable environment to present them in, in order to nurture engagement in children with ASD. In order to do this, a process of iterative design through action research was undertaken, as discussed in the previous chapter. The following table summarises the requirements that emerged from this process and shows how they have been mapped to the designs in Project Spectrum. Following this summary, there then follows a description of each module, and more detailed discussion of their design and purpose.

Table 6.1 - A summary of the elicited community requirements and how they map into the Project Spectrum designs

Requirement	Source(s)	Solution(s)	PS Module(s) & Environment
To nurture the engagement of children with ASD	Project remit	To embark on a process of action research amongst the community in order to further inform the design and delivery of the modules and environment.	The creation of a set of tailorable interactive digital modules, presented within a low arousal environment designed to meet the elicited requirements of the community.
To provide a set of tailorable interactive digital modules			
To provide a safe environment for children to experience the modules			
To create a low arousal environment in which to deliver the modules	Literature review and State of the art review	Create new designs for low arousal environment based on literature review and community action research	Original low arousal environment designed and installed, including digital modules.
	Discussions with parents and teachers		
To locate the environment in a school	State of the Art review	Locate a suitable establishment to host environment	Environment installed in a mainstream primary school at the heart of the community and inclusively catering for children on the autistic spectrum
	Community based action research	Make links in the community to establish environment within school	
Difficulty with social interaction, communications and imagination	Literature review	To investigate ways of stimulating social activity through the use of interactive digital technology within a bespoke environment	To employ a facilitator who understands the social needs of the children, and can use the digital modules and environment to meet these.

Requirement	Source(s)	Solution(s)	PS Module(s) & Environment
Preference for different colours	Jackson	Several modules created that specifically display colour	Mirror (Glowing) Mirror (Trails) Mirror (Kaleidoscope) Spots / Cogs Stepping / Following Vocalising
	Interview with mother and sons	All colours in modules tailorable	
	Interview with Dr Pauli	Minimal colour used in environment	
		Environment colour tailorable with lighting	
		No arbitary use of colour in modules or environment	
Preference for round shapes	Jackson	Modules created showing round shapes	Spots Stepping / Following
Preference for spinning shapes	Jackson	Module created showing spinning shapes	Cogs
	Interview with mother and sons		
Preference for mirrors	Jackson	Modules created that mirror image and / or movement of child	Mirror Mirror (Wobble) Mirror (Dots) Mirror (Glowing) Mirror (Trails) Spots / Cogs
Preference for sound and light equipment	Jackson	Modules presented using digital projection system	All modules
		Modules presented using digital sound system	Tailorable lighting system in PS environment
		Tailorable coloured lighting system created	
Preference for nursery rhymes and meditation music - dislike of loud noises	Jackson	Soft sounds used in some modules	Spots
			Stepping / Following
Need for a wider selection of sounds	Prototype testing days	More ‘robust’ sound included	Spots / Cogs

Requirement	Source(s)	Solution(s)	PS Module(s) & Environment
		Selection of animal / transport sounds included	Stepping / Following
Various sensory sensitivities associated with ASD	Literature review	Low arousal environment created for presenting the modules in and for use as a sensory haven to ‘chill out in’.	Visual and audio aspects of modules tailorable
	Jackson		All unnecessary visual stimuli removed from environment
	Interview with mother and sons		All unnecessary furniture and equipment removed from environment
	Discussion with children, carers and teachers		Dimmable daylight bulbs installed in environment
			Blackout blinds used to reduce changes in lighting
			Neutral coloured flooring installed
Difficulty with coordination and a variety of coordination needs	Literature review	Specific modules created to encourage gross motor skills and spatial awareness	Camera tracking used to provide ‘hands free’ interactions with computer controlled system
	Jackson	Modules provoke movement of arms, legs and whole body	Movement space created
	Discussion with children, carers and teachers	Suitable space provided for coordinated interactions	All mirror modules Spots / Cogs Stepping / Following
		Modules created that can be engaged with when sitting or standing	

Requirement	Source(s)	Solution(s)	PS Module(s) & Environment
Need to gain control over environment	Jackson	Tailorable child centred environment created	Environment adaptable to needs of child - choice of seating locations, movement area, chill out area.
	Interview with mother and sons	Tailorable modules created, of which child can request particular colours / sounds / complexity	Tailorable lighting to suit child
		High level of control over modules through interactions	All modules tailorable in content / complexity / duration
		Child able to make choices about which modules to engage with	PECS cards created for modules allowing child to choose which to use during sessions
			Facilitator trained to work with children to understand and realise their needs
Need for predictability	Literature review	Find suitable location to support PS environment, providing predictable and consistent experience	Permanent environment created to provide consistent experience
	Jackson	Employ facilitator to regularly work with children	Same facilitator used throughout sessions
	Discussion with children, carers and teachers	Structure sessions and timetable them into the child's day	Modules tailorable to provide consistent experience

Requirement	Source(s)	Solution(s)	PS Module(s) & Environment
		Create modules that are consistent and predictable across sessions	Clear sequence of modules organised so that child knows which module they will use when
			Each session follows a consistent routine and timescale
Difficulty with interaction	Literature review	Create an environment that supports person to person interaction	Shared and movement space created to give children a range of locations from which to interact with others
	Jackson	Create an environment that supports a range of interaction styles	Private space acknowledges that sometimes not having to interact with others can be the stimulus to future interaction
	Discussion with children, carers and teachers	Create modules that encourage interaction between the child and the modules	Facilitator understands interaction needs of children and how to use modules to address them
		Create modules that encourage person to person interaction	All modules encourage children to interact using movement or vocalisation

Requirement	Source(s)	Solution(s)	PS Module(s) & Environment
		Employ a facilitator who understands the interaction needs of the children	All modules can be interacted with by the child and the facilitator and encourage them to interact with each other
Need for parallel play	Literature review	Create an environment and modules that allow for parallel play	Areas of the environment specifically designed for parallel work and play
	Jackson		Modules open to solo and parallel play
Preference for computer based games	Interview with mother and sons	Create modules that are computer based and identifiable as games	All modules are presented through a computer and digital projection system, and use computer graphics and sound to engage the children
Need for neutral sensory environment to promote concentration	Interview with mother and sons	Create a neutral sensory environment	PS low arousal environment can be used for a range of activities including use of the modules
Dislike for losing games	Interview with mother and sons	Create open ended activities	All modules can be used open endedly
	Discussion with children, carers and teachers		

Requirement	Source(s)	Solution(s)	PS Module(s) & Environment
Need for computer games that encourage crossing the mid line	Jackson	Create modules that encourage and reward children for doing this	PS modules Spots and Cogs can be used to do this
	Interview with mother and sons		

The Stepping Module

The ongoing literature review and findings of Jackson, revealed that many children with an ASD experience clumsiness and that such motor coordination difficulties may result from abnormal proprioception (Weimer et al. 2001). These findings indicate that children with an ASD have an over reliance on vision for spatial awareness and balance. In response to this and my own observations of how children engaged with the 'chase the balls' module, the first prototype developed for PS was the 'interactive drum machine' (see supporting AV material p.17). This prototype did not have a digitally projected visual element, but rather required children to be aware of their position within a three dimensional space and to move around this to engage and interact with sounds. Unlike 'chase the balls', this prototype could also be successfully used by more than one child, and allowed them to cooperate in the creation of drum patterns, with the hope that this could become a social experience for the children in which they used the prototype as an interface for social engagement.

The design of this prototype was more complex than its predecessor as it allowed the facilitator to identify discreet areas of interaction or 'hotspots' within the environment. Whereas 'chase the balls' had allowed children to interact in any part of the environment that the camera could see, the facilitator now had far greater control over how much of the space was interactive and was able to create as many 'hotspots' as they needed of whatever size they thought appropriate. The prototype therefore introduced a level of tailorabilty previously not available.

Over a series of informal user testing sessions two immediate problems were revealed with the ‘drum machine’. Firstly that the use of drum sounds was not always appropriate. The ability to be able to trigger percussive sounds repeatedly (as shown in the AV document) often resulted in chaotic noises, which whilst fun for some children was not suitable for others. The other was that whilst the facilitator was able to quickly create virtual hotspots using the computer interface, these then needed to be clearly signified in the ‘real’ space using markers on the floor.

In response to these issues, the ‘drum machine’ morphed into the ‘stepping’ module (see supporting AV material p.20). A new selection of sounds was made available to the facilitator and these were tailorable to match the preference of the child. For example for one child a selection of animal sounds was used (see supporting AV material p.29). The ‘stepping’ module also introduced the potential for a visual element to be included in response to the child’s interactions. This was because some members of the adult community observing sessions had commented that a visual element would enhance the engagement of the child, and reinforce their understanding of the cause and effect relationship with the module. During prototype testing a series of colours were projected to correspond with the musical notes, and these were mapped from low notes being represented by darker colours such as purple and blue, up to the higher notes being orange and yellow. Whilst these mappings were somewhat arbitrary and could be altered by the facilitator, they were inspired by the work of Pauli and Smith (2002), who used different coloured lighting to change the mood of children with ASD, and by writings on synaethesia by researchers such as Birren (1978, p.147) who argues that our perception of colours can be affected by the pitch of sounds that we hear, and that higher pitches correspond to lighter colours. Recently Robson (2009) found a genetic link between autism and synaethesia. However such specific enquiry into the use of colour and sound is not the subject of this research, but does provide context and suggestions for future work in this field. The final ‘Stepping’ module allowed the facilitator to insert a selection of their own images into the software and to map these to the hotpsots with or without corresponding sounds, giving the highest degree of flexibility to the module.

Whilst the original ‘drum machine’ prototype allowed the facilitator to create as many hotspots as they wished, this was limited to nine in the first ‘stepping’ prototype and finally five in the final module used for evaluation. In order to ensure reliability from the hotspot system, it was necessary to use uniformly sized and spaced out hotspots. It was only therefore possible to accommodate nine hotspots within the cameras field of view. In the final environment, space limitations meant that it was only possible to accommodate five hotspots within the ‘movement area of the classroom’.

For the evaluation, the stepping module was first used with just one hotspot, which would then be increased to two and so on over sessions. This allowed the child to build up their understanding of how the module worked. Large coloured spots were used on the floor to mark the hotspots and the facilitator would demonstrate their use to the child. Subsequently the facilitator would join the child on the hotspots for turn taking and sharing activities.

Whilst developing the module and working with the facilitator it was observed that the children enjoyed having control over the digital module by stepping on the hotspots. They were able to dictate progression and responses by making choices of which hotspot to step on in a sequence. We were interested to see how the children might respond when they were not able to lead the engagement, but instead had to respond to instruction. This would challenge their flexibility to respond to unpredictability, and to adapt to decisions that were not their own. Rather than issue instructions a program was created based on the stepping module that would select one of the hotspots at random and produce the sound or image that was associated with that hotspot. The child then had to step on the corresponding hotspot, in order to initiate the next image or sound in the sequence. This module was called ‘Following’ and was used with the children during the evaluation after they had become familiar with the ‘Stepping’ module.

During testing a further application emerged in which facilitator would engage with the ‘Stepping’ and the child would direct them to find certain sounds triggered by the hotspots. For example, when animal sounds were being used the child would challenge the facilitator to find the cat. Allowing the child to lead the session was an important next step, and although not discussed in this research, is an important area of enquiry to be pursued.

The Spots module

Observing children engaging with the ‘chase the balls’ prototype, parents and carers commented on how engaged the children became with the screen based media and how it encouraged them to explore movement of their bodies. A request was made for a module that would demand more precise movement, and in particular that might challenge children to cross the midline. This involves using part of one side of the body in the space on the other side of the body. For example drawing a line with a pencil from the left side of the body to the right without swapping the pencil from one hand to the other. Difficulty with this is common amongst children with autism (Whitman 2004, p.59). Whilst training a computer vision system to recognise which side of the body is being used to perform such as task was too complex a task to be viable within the remit of this project, it was more straight forward to develop target areas which could be used by the child to practice crossing the midline and other specific coordination activities.

Also during this early period of development, Jackson’s research revealed that the children had a preference for using mirrors, and being able to see themselves. I therefore started to consider that as the camera was filming the child to record their movements and translate them into digital activity, we could use the ‘live’ image of the child on the screen as part of the visual engagement, perhaps using it within the interface of the modules.

Considering this, the first prototype developed was the SoundToy (see supporting AV material p.19) which encouraged children to use their left and right arms to generate distinct sounds, raising the pitch of these sounds by raising their arms. The child was able to see himself, and the interactive areas on the left and right were signified by shading them with colour. Whilst this prototype was reasonably successful it did not offer the level of flexibility and tailorability I wanted from the final module. For example the areas of interaction were necessarily static and only encouraged the child to move their arms in a particular direction. However in testing it did demonstrate that children enjoyed seeing themselves on the screen, seeing themselves move, and how this movement corresponded to the responses from the computer. Whereas in ‘chase the balls’ they had to infer the relationship between their movement and the response on the screen, this relationship was now laid bare by placing them alongside the media on the screen.

The ‘Spots’ module (see supporting AV material p.27) evolved by creating more specific areas of interaction than the ‘SoundToy’ and the first iteration was presented during the Closer! project (Drago et al. 2005). This version offered the child five coloured spots that responded with animation and sound when the child interacted with them. Tested with a wide variety of children on the autistic spectrum, this proved a popular module, although for some the position of the spots was not suitable, with the facilitators requesting the ability to move the spot to the child to initiate interaction rather than the child having to move to the spot. Also the choice of sounds and colours was not always favoured by the children.

The final version of ‘Spots’ addressed these short fallings by allowing the facilitator to control the number of spots used, their position, colour, and whether they would respond with sound and if so what that sound would be. A second ‘flavour’ was also introduced named ‘Cogs’ (see supporting AV material p.27) in response to Jackson’s (2009) findings that children had a preference for cog shapes and for looking at spinning shapes.

By positioning Spots in particular locations, the facilitator was then able to invite the child to perform certain coordination tasks, such as touch the blue spot with your left hand, or jump to touch the yellow spot with your head. These tasks could involve crossing the midline if appropriate, and in testing children enjoyed this challenge.

A further module, ‘Chase the Spot’ (see supporting AV material p.28), was then developed. Some of the children using the module during testing only engaged for a short period of time with the ‘Spots’ module. Especially for some of the more able ones, once they had seen what the module did, there was no longer any challenge for them and they were not interested in using it any more. In response to this, ‘Chase the Spot’ was developed as a game that demanded more attention, and if played competitively, quick reactions and coordination. In this module just one of the spots was used and it would appear at a random location on the screen. When it appeared the child had to 'touch' it with their mirror image and it would then reappear in another location. For some children this was enough of a challenge, but the module could be tailored to meet the needs of the more competitive, by enabling a scoring system and a time limit. Also the facilitator could take manual control of the module, and decide where the next spot would appear, making the game harder or easier for the child as appropriate. In this more competitive mode, children could take turns with the facilitator to see who could get the most points in the given time limit. Just as with the other modules, this was designed to lead to greater social interaction and engagement with the facilitator thus meeting one of the requirements of the project.

The Mirror modules

Having developed the 'Spots' and 'Cogs' modules, that allowed the children to see themselves on the screen as part of the media, I now had to consider how I would introduce the large scale projection and camera tracking system that would be used as the interface between the children and the modules. Whilst such an interface had been used in the Sony EyeToy, not all children had experience of this. It was therefore important to present the interface in the simplest form possible, and this was the inspiration for the various mirror modules. All of the modules using the 'Mirror' are exploratory and open ended, allowing the child to explore different reflections of themselves.

The first of these simply provided a full screen image of what the camera could see (see supporting AV material p.24). Standing in front of the camera, the children could see themselves projected onto the screen, and get used to watching their reflection respond to their movements. They could become accustomed to the scale and quality of the digital image, and also the slight lag in timing compared to when one uses a real mirror. This lag was a technical feature caused by time taken for the image to travel between camera and projector via being processed by the computer.

Having introduced them to the digital mirror, and the range of vision from the camera, and when they were in or out of shot, it was important to next demonstrate that this mirror, unlike a real mirror, could alter what it showed you and that your image could be manipulated. I was aware through my research and the requirements passed to me by Jackson that change could be something that the children may have difficulty with, and that this should be introduced slowly, rather than jumping directly to the complexity of modules like ‘Spots’. Therefore the first change introduced in the ‘Mirror’ was some distortions similar to what you might find in a hall of mirrors. This was called ‘Wobble’ (see supporting AV material p.24) and allowed the facilitator to gently manipulate the child’s image, whilst they could play in front of this image and explore their new reflection. In response to the elicited requirements, this was designed to be fun for the child, whilst enticing them to move their bodies. As part of the engagement process that the environment is designed to nurture, the facilitator is then able to use the images produced as a point of discussion if appropriate, thus encouraging verbal engagement from the child which may be extended beyond the use of the modules.

The next module named ‘Dots’ (see supporting AV material p.25) continued to explore changes in the mirrored image. The module was inspired by similar work in “The World, Their World” (Drago et al. 2003), which had been designed to encourage young children with learning difficulties to move around, and had been found successful in evaluation. One of the user requirements listed by Jackson was to encourage gross motor skills, and this module was designed to encourage children to move their limbs and entire bodies. The elicited user requirements had also revealed that the children wanted to have control over their experience and that they had a preference for abstract images. The ‘Dots’ module was designed to introduce this abstraction. It was based on the child’s reflection which they had become used to in the previous two modules. Because the module is controlled by the speed of movement from the child, they have greater control over how the module responds by changing the speed at which they move in front of the camera.

Visually the module shows the child’s image, which then breaks up into little dots when the child moves around. The greater the speed, duration and extent of their movement, the more dots appear and the longer they appear for. The facilitator is able to tailor the sensitivity of this response from the system, so should a child be unable or unwilling to produce large movements, the system can be sensitive to smaller movements as well. During the movement, the parts of the body in motion become dots whilst anything static stays visible. Therefore the child is able to make different parts of their body distort for example by waving just one arm or leg or by shaking their head. If the child chooses to jump in the air or run round the space, their whole body will disperse until they stand still again.

The ‘Dots’ module is also designed in response to the user requirements to encourage interaction between the child and another person. This interaction can take place using the screen as an interface so that the child can avoid direct eye to eye or verbal interaction, both of which were revealed in the literature to be unsuited to some children with ASD. The children can work alongside the facilitator and can engage in turn taking and copying activities, both aspects of social interaction identified as being difficult for children with ASD, using the effect of the module to highlight their interactions. There is even the possibility for the child and facilitator to hold hands and move together, making both of their bodies control the module, and making the experience tactile as well as visual. In testing this was popular with some children, whilst others were not happy to make physical contact.

The next two modules in the ‘Mirror’ section of PS allowed the image of the child to become increasingly abstracted by representing it as colour. Different colours could be selected in response to research which indicated that children had a strong relationship with colour and preference for particular colours. The first module ‘Glowing’ (see supporting AV material p.26) functioned in a similar way to “Dots’ in that it responded to the movement of the child, only this time when they moved their image would appear as a glowing silhouette. The colour of the image could be tailored by the facilitator to suit the child, as could how much of their original mirrored image is visible. Using a simple slider the facilitator can choose how much of the child’s original ‘mirror’ image is visible, and can choose to make it totally invisible and represented purely by colour. Once these parameters are set the child can explore how their reflection is being transformed by moving around in front of the camera. In testing we found that children enjoyed looking at themselves represented by different colours and would often verbally request a new colour from the facilitator. Carers commented that this type of request was good as it showed the child was enjoying the experience and that they were initiating change and making decisions about their experience. This showed engagement from the child, thus suggesting that the module was meeting the remit of the project.

The "Trails' module (see supporting AV material p.26) is very similar to the "Glowing' module, only this one allows children to leave a trail of colour across the screen with their movement and in effect to paint either with gross or fine motor movements onto the digital canvas. This led to a greater range of movements than 'Glowing'. Again the facilitator was able to choose which colours were used and how much of the original image was used, and this would often be in response to requests from the children.

The final Mirror module is the 'Kaleidoscope' (see supporting AV material p.29), inspired by the Iamascope (Fels and Mase 1997), and developed both as part of Closer! (Drago et al. 2005) and for Project Spectrum. In discussion Jackson too had identified kaleidoscopes and symmetrical patterns as something that children may have a preference for.

For PS, the kaleidoscope had two settings. Like the Iamascope it could take live video from the camera and place this into the kaleidoscope. A child standing in front of it could then see parts of themselves appear within the image. However in response to Jackson's (2009) identification that some children required solid and distinct colours, the kaleidoscope could also be set to use one or more colours instead of the live video. This produced a much clearer and more vivid image. The facilitator was able to set whether to use live video or solid colours, and then how many and which combinations of colour to use. When the child moved in front of the kaleidoscope they could control its tessellation, the sensitivity of which could be set by the facilitator.

Vocalisation

Another area of prototype development was to create a system that allowed children to control visual media through their vocalisations. Jackson (2009) describes children with ASD as poor or reluctant communicators and some having little tonal variation. The 'Vocalisation' module (see supporting AV material p.30) was created in response to this identified difficulty, in order to encourage children to play with their voices, receiving visual rewards from the computer in response.

By developing software that could measure the pitch and volume of the sound produced, children are able to cause different effects by using different tones of sound. In the prototypes children could control the colour of an object, the higher the pitch of their voice, the lighter the colour produced or the louder the sound they made the bigger an object would become.

For the final module used in evaluation a series of twinkling stars were shown on the screen, and a particular one would animate depending which pitch the child produced. This clearly illustrated the relationship between pitch and the visual response as the stars got higher into the air with pitch and their colour lighter. We decided not to use modules that responded to volume as in testing this had just encouraged some children to shout and for others to be intimidated by the demand for a loud noise. I also made the kaleidoscope sound reactive rather than responsive to movement, as we had found that certain children really engaged with this imagery.

Summary

The following table summarises the modules used in the evaluation and their reason for inclusion:

Table 6.2 - Summary of Project Spectrum modules used in evaluation

Module	Aim
Project Spectrum Environment	To nurture social engagement with others using the modules as stimulus
	To provide opportunities for conversation with the facilitator
	To enjoy sessions in the Sensory Classroom
	To provide experiences unavailable elsewhere
	To provide a highly flexible and tailorable set of modules suitable for a wide range of children with ASD
	To provide a safe environment for children to experience new activities and to experiment with them
	An emerging need to move from adult led sessions to child led sessions and play.
Mirror	To introduce the child to the interface
	To introduce the child to the various equipment
	To provide a highly visual stimulus

Module	Aim
	To get the child used to seeing themselves on the screen
	To encourage spatial awareness
	To be able to indirectly interact with another through the mirror - ie not have to stand face to face, but rather to use the mirror as intermediary
	To encourage imitative play
	To introduce change to the reflection gradually and safely
	To be able to abstract the child's image and play with that abstraction
	To have fun playing with the various effects available
	To empower movements with bold visual responses
	To empower stillness with visual responses
	To promote understanding of the cause and effect relationship between movement and the visual response on the screen
Spots	To facilitate coordination
	To encourage gross motor skills
	To encourage use of different parts of the body to engage
	To facilitate crossing the mid line
	To promote an understanding of cause and effect
	To provide open ended and competitive experiences as appropriate
Stepping	To increase spatial awareness
	To encourage gross motor skills
	To challenge some children to be led by the computer
	To offer visual and / or sound responses for movement
	To start allowing children to lead sessions
Vocalising	To encourage vocalisations
	To increase the tonal ranges used by children
	To encourage playfulness with the voice
	To encourage imitative play

Chapter 7 - Evaluating Project Spectrum

Introduction

The previous two chapters have discussed the creation of the Project Spectrum environment and interactive modules in response to the user requirements elicited through community centred research and the review of the literature. This chapter discusses the subsequent evaluation of the project. The evaluation is discussed in Woodcock and Woolner (2008), and is included here in the Appendices.

On completion of the installation of the Project Spectrum into a mainstream primary school, there then followed a period of evaluation during which two pupils at the school regularly attended sessions in the environment and used the modules alongside the facilitator. That evaluation is the focus of Jackson's research (2009) and therefore is not discussed in detail in this thesis. Instead the focus is on the qualitative evaluation of the project, and in particular the response of the community for whom and with whom it was designed. This comes as part of the community centred approach taken throughout the project, and informs how work in this field might continue in the future. This examination of the stakeholders experiences addresses one of the main objectives of this research.

As part of a community centred research and design project the Project Spectrum environment was delivered "in situ in a mainstream primary school, far removed from the controlled 'laboratory' required for the evaluation." (Woodcock and Woolner 2008) The project team considered it vital that the environment was tested in an actual usage context, rather than one that attempted to meet evaluation needs, and that children were not brought out of familiar and comfortable environments and routines in order to participate in the project. Insisting on taking children with ASD into situations that are unfamiliar would unnecessarily distress them, and lead to unnatural behavior. This did place some restraints on the evaluation as we were not, for example, able to have access to the video and annotation facilities, and the controlled environment that a usability lab would have provided.

However by conducting the evaluation in the school, we were able to demonstrate how such a project can be delivered within the everyday experience of users. This approach gave the ownership of the project over to those who would eventually inherit the legacy of the environment. The exposure to a number of different user groups during development helped to demonstrate how Project Spectrum could be applied to a wider audience within varying physical spaces, rather than in the artificial set up of a laboratory.

<u>Application of the Hexagon-Spindle Model of educational ergonomics</u>

Having made the decision to install Project Spectrum into a mainstream school, it was important to contextualise its existence as part of that learning environment. The sessions that took place using the interactive modules were always designed to develop the engagement of children. By positioning these within a dedicated environment, located in an institution with its own remit for the education of children, the learning that took place was formally recognised within the context of the other work taking place at the school. Furthermore it allowed PS to exist as part of the daily routine of a school pupil, and by becoming part of that already existing community, allowed the designer to be more aware of the child's experience before and after using the environment as well as during. The environment too became part of the school's identity, and its positioning and acceptance into the school also had to be considered.

By adopting the Hexagon-Spindle Model (Benedyk et al. 2009) of educational ergonomics, a structured and holistic view of the child's experience surrounding their use of the environment was taken (Figure 7.1). The model places the child as learner at the centre of their learning tasks and makes explicit that fullfillment of these tasks may be influenced by a number of factors of various importance to the individual and to the task. Influences include environments, teachers, peer group and the temporal location of the task within a school day. This allows conflicts between these various elements to be identified.

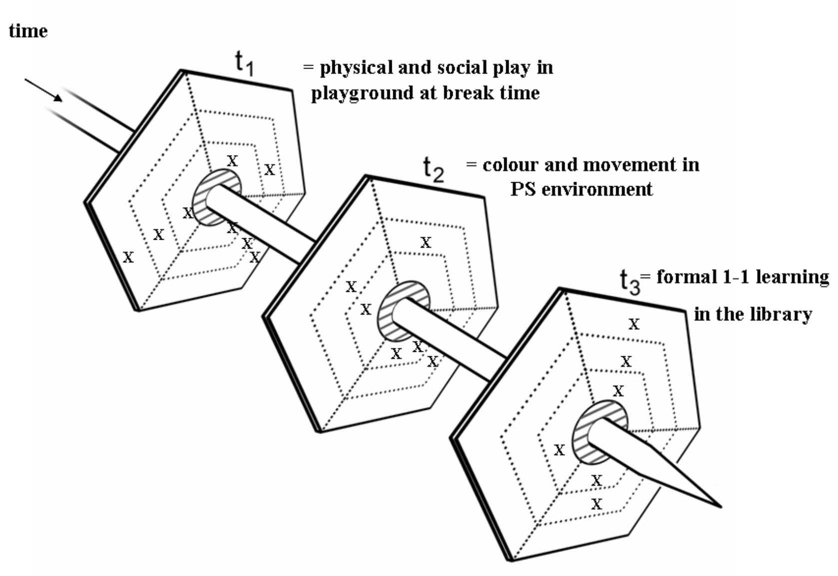

Figure 7.1 - Application of the Hexagon-Spindle Model to Project Spectrum

The wide range of needs experienced by children with ASD makes a 'one size fits all' approach redundant when considering the design of an environment to meet their requirements. Therefore a design needed to be created that could be tailored to have a range of children at its centre. The Project Spectrum environment had to be designed both to meet these requirements and to deliver the interactive modules, which were themselves based on user requirements. In order to do this it was first stripped back to create a low arousal room in which sensory stimuli were limited as much as possible, but which was still well lit for visibility. Into this space were installed the apparatus needed for the PS modules to be delivered, including the projection system, sound system and coloured lighting system. These systems could then be tailored using the project software to meet the individual needs of children.

From an ergonomics perspective this meant that the children's characteristics had shaped the form of the environment and the type of work that would take place within it. In this way we hoped to be able to deliver to the most disenfranchised and least able children and potentially be accessible to a high number of students with a range of abilities.

Having placed the child at the centre of the design we then consider the external influences on the project. At the outermost level is the current interest in autism, its increased prevalence, and the effect this is having on Britain's communities and education system. Without this it is unlikely that this work would ever have received its initial funding. Alongside this is government policy on the inclusion of children with special needs in mainstream education, and the need to provide them with adequate provision. This in turn is reflected in the policy of schools to include children and the efforts of staff to find a means of doing this effectively. Without this initiative it may have been impossible to locate Project Spectrum in a mainstream school. However in the event the project benefitted from the support of the local authority through the local autism inclusion unit, who advised on certain aspects of the design and approved the project taking place within the school, involving pupils with ASD and members of their own team in the evaluation. The project also benefitted from the inclusion policy of the school, and the informed and progressive thinking of its head teacher who approved the transformation of one of the classrooms into the PS environment and subsequently supported its use by staff and pupils.

The inclusion of technology in the environment is very much shaped by the current proliferation and relative affordability of the equipment necessary to provide new experiences to children. This is coupled by the interest of academics and funders to support this type work and foreseeing worthwhile applications arising. As identified in the review (presented in chapter 2) technology has been used to engage children with ASD, and has become part of the everyday experience of children growing up in the U.K.

Within the school, the environment must comply with health and safety regulations and ethical recommendations such as not having screened off areas in the classroom. The classroom model created should be affordable and therefore replicable within existing financial frameworks. Furthermore the environment and the modules should support achievements that have a recognised value in the school hosting the environment as well as by those specialising in autism, the children and their parents. The views of this community were all included as the design progressed.

Positioning the environment and its use into the infrastructure of the school and the timetable of the child were also essential. For children with an ASD predictability and structure can be essential. Introducing a new experience in to their timetable has to be done gradually and sympathetically. Some might quickly adapt and others may take more time. Others might show an initial enthusiasm to be involved which might be quickly extinguished by the reality of having to do something new, or not being precisely what they expected. This introduction of 'something new' includes going to a new room, meeting new people, doing new things and maybe more importantly, not doing what we usually do. During the Project Spectrum evaluation, the ritual of coming to the new environment became an important part of the process for the children, and how this went could colour the rest of the session. Likewise events that had proceeded this even before school could result in unexpected behaviour from the child during sessions. It was hoped that the low sensory environment and the structures put in place before, during and after sessions might help to address some of these behaviors, and it was found that for some children using the modules would help to calm them down if they were feeling stressed before a session.

When using the modules it is also important to consider the experience of the facilitator, without whom the child will not have an engaging session. The facilitator must understand the purpose of the environment and be trained in the use of the modules. They must be allocated time within the school day, allowing them to set the equipment up, run the session and record their thoughts and findings. They should also have a good relationship with the child. The children will respond differently if asked to work with a stranger in the environment. Like other elements of the session this should be predictable and consistent.

Alongside the experience of the primary users of the environment is that of the secondary and tertiary users who support its use. For example maintaining the technology, cleaning the space between sessions and sacrificing the room within the school for this purpose. Each of these also has a relationship with the environment that evolves over time and has to adapt to new circumstances.

Whilst the Hexagon-Spindle model can be used to give a detailed and holistic view of individual experiences of the environment in the context of the school, it can also be used with a different time scale and precision to breakdown the child's experience of individual sessions to elicit their requirements of and engagement with the modules and the environment. For example, as part of the evaluation process, sessions were videotaped and later analysed to discern moments of engagement from the child with particular modules and aspects of modules. Whatever the scale, the model allows us to ascertain the effects of activities on those that follow, and to gain a more holistic view of a child's experience, rather than considering events in isolation. This justifies the installation and evaluation of the environment in a working school rather than in the artificial confines of a usability lab. In this scenario we are able to ascertain the role the environment takes within the school and this is in keeping with the community centred approach taken throughout the project. In this way the environment and modules exist within their own Hexagon Spindle model and the effects of sessions and the school upon their design, realisation and use can also be monitored.

Structure of the evaluation

In order to be successful the design had to be accepted by the different user groups at the school. This included the head teacher, teachers, support staff, parents and pupils as well as the children involved in the evaluation of the project. It had to justify its presence in the school, the space it occupied, the support it required and its usefulness to the children and staff. The evaluation therefore took a holistic approach the 'formal' part of which examined the children's engagement with the interactive modules and had five aims (Woodcock and Woolner 2008):

1.) To provide formative assessment to inform the design life-cycle. Here the need is to provide material that can be used to enhance design of the environment and the digital modules. For example, producing material that will link the environment with other activities within the school; modifying the environment to accommodate suggestions made after regular everyday use.

2.) To assess the extent to which the environment and the modules succeeded in nurturing the engagement of children with an ASD by addressing the triad of impairments and providing opportunities for engagement.

3.) To contribute a generic methodology which could be used to assess similar environments.

4.) To assess the extent to which the modules met the underlying requirements.

5.) To provide insight into the operation of the Project Spectrum environment in the wider school environment.

To meet these aims a variety of qualitative and quantitative methods were used (Table 7.1) which together formed a generic evaluation methodology for systems of this type. The structure of this was shaped by the Hexagon-Spindle model.

Table 7.1- Evaluation methodologies employed in Project Spectrum

	Organisational		Contextual		Personal	
Design Issues for PS modules in a particular environment	Learning environment management	Learning environment infrastructure	Tools and materials (Product) design	Teaching (task) design	Social and Groupwork	Learner individual
External environment factors important for the design of PS	Semi structured interviews with head teacher, national agencies to evaluate the extent to which the room met the wider needs of effective learning environments		Demonstratio n of the room to peers at conferences	Informal iterative evaluation with teaching assistant and other teachers to asses the extent of fit with QAA objectives	Informal interviews with parents of the children involved in the study. Checklists to measure behavioral change during the course of trials.	
Learning work setting level for PS	Semi structured interviews and observations with teachers to assess the operation of the room in the school				Semi structured interviews and observations with teaching staff.	

	Organisational	Contextual		Personal	
Learning workplace level for PS	Observational studies show the use of the room over the course of the day. Informal observations and interviews with teaching staff to assess the usability problems and scope for design improvement	Usability assessment from video analysis and diary observations	Informal interviews with TA and teachers directly involved in the room and working with the children	Interviews with parents to assess perceived change in the child over time eg increased talk	Diary studies, rating scales etc to show behaviour individual sessions filled in by TA
Learning workstation level for PS	Observational studies and interviews with key staff	Video analysis focusing on usability problems	Informal interviews with TA regarding opportunities for scaffolding etc	Video analysis of sessions to identify changes in behaviour eg time on task, levels of co-operative play and imitative behaviour	
Learner interaction of pupil in PS classroom or with modules					
Learner level for PS	Students were mostly unable to provide reliable feedback or commentary on their enjoyment or otherwise of the modules				

An autism treatment evaluation checklist (ATEC) (Rimland and Edelson, 1999) form was used along with a sensory profile checklist to create a profile of the child before and after testing in order to measure any changes. During the trials a daily questionnaire and diary was kept by the facilitator to record day to day experiences and changes. This included factors that may have influence on a child's behaviour during a session such as being agitated or unwell prior to the session. Children would inform this through their comments during the session as would staff working with the children before and after the session, who might feed back the next day on behaviour after the previous session. It was not expected that any significant changes would be registered on these scales over the trial period of one school term. The questionnaires were the work of the Project Spectrum team and are discussed in detail in Jackson's research (2009). They are mentioned here for completeness.

Each session was videotaped using two cameras, from the front and from the side, in order to observe the child's movements around the environment and their faces during the sessions. This was later analysed using simple, emergent behavioural categories such as looking at the screen, engaging with content and imitative behaviour. The analysis involved sampling behaviour every ten seconds of the fifteen minute session. This was complimented by the diaries and checklists produced during the session and by interviews with parents, teachers and support staff to ascertain their opinions on the impact of the project on the child. The four outcomes expected from this process were:

1.) That children would engage with the interactive modules

2.) That the children would enjoy their sessions in the environment

3.) That there might be some reduction in the difficulties experienced by the children in relation to their ASD

4.) That some of these findings could be demonstrated through the evaluation

I managed these sessions throughout, and was responsible for their documentation. I discussed them with the facilitator as part of the ongoing reflection on action, and together we would make informal and sometimes formative evaluations for the purpose of further developing the system and the structure of sessions.

The trial involved two pupils at the primary school in which the environment had been installed, both of whom had been diagnosed with an ASD. It took place over six weeks with the children using the room daily with the facilitator for around 20 minutes at the same time each day. The first child would use the environment before lessons in the morning, the second during the lunch break. It was not possible to test each module systematically as the facilitator moved through the different modules at an appropriate rate in response to the child. However they did progress through the modules in order and for the most part focussed on one module per session. Once the children had engaged with all of the modules they were then invited to choose one or two modules to engage with during a session. Each module was tailored to the individual requirements of the child, as were individual sessions, and if a child did not wish to engage with a particular module, the facilitator could choose to use a different module instead or to abandon the use of the modules for that session. Whilst this approach does provide a higher degree of ecological validity to the study, it also means that any one behavioural measure is unlikely to indicate benefit from using the environment

Locating the evaluation in a working school meant there were various factors that could not be controlled. As previously mentioned one child used the environment during the lunch hour and the noise from the playground could be heard in the environment. Occasionally there would be interruptions from visiting adults or nosy children. If the regular facilitator was not available another member of staff would run the session with the child, and although copying the facilitator's approach, would have a different relationship with the child. This would affect the behavior, and they would complete questionnaires from their own perspective. In addition we could not control the child's everyday school experience, and children might come to sessions stressed by events in the classroom or playground; having taken prescription medication; or having had some other experience that might have upset their sensitivity. It was therefore difficult to attribute behavioural changes to the environment, although anecdotally it was observed on some occasions that children did have reduced stress levels after having spent some time in the environment and the company of the facilitator.

The behaviours measured in the evaluation included imitative play, time on task and direction of gaze. We did not measure facial expressions as these could not be assumed to be indicative of the child's emotional state. Therefore the quantitative data was supplemented with semi structured interviews with teaching staff and parents to assess changes in the children and these were recorded as part of the evaluation (see supporting AV material p.31). These yielded positive feedback. For example one parent said:

> "He feels a sense of ownership of the sensory room. He enjoys all the stimulating things, all the technology. He talks about it as if it's his room, and he talks about school in very positive terms, 'my school, my classmates' which is wonderful to hear because he has never found that sort of affinity with the school", and "He's feeling much more part of the group now, because he's had a safe haven where he can do all the things he doesn't want his peers to know about, where he's not self conscious and he's not embarrassed because he's struggling with maths, but then he can go out and share It's an immense move forward."

Another parent said:

> "He tells me every night when we go home from school. I ask him 'what have you done today Barry?' He told me the names of the two of the other children who

came into the sensory room with him and then he said kaleidoscope and colours. And when I asked the next day, they had done kaleidoscope and coloured spots with two other children. So what he told me was right, but I thought I'd better check, and it was right! I thought that was great, that's a positive for me because he never tells me anything about anything. He's started to now. He only started to speak last year. 'I've been in the sensory room today mummy,' he says, which is a lot of words compared to what he used to say. Now that's great for me"

The facilitator, an autism support worker, said of working in the environment:

"It's been a real help for me when working with the children. Having a room that we can come to that considers their needs is a great bonus. The computer activities have been very popular and have given me a new way to work with the children that I've never had before. I certainly think it should be considered for wider use."

These responses suggest that Project Spectrum had promoted engagement amongst the children and also amongst the staff and families. The diaries kept by the facilitator and other staff members revealed that children enjoyed and looked forward to the sessions and that the observers felt the children had engaged with the various modules. These also served to inform the ongoing design of the modules, with changes being made to meet concerns raised such as whether a module used the right sounds or the competitive and cooperative aspects needed tweaking. The evaluation also revealed how the teachers and autism workers involved in the project had gained a greater understanding of the potential for interactive technology to engage the children. The environment did provide original interactive experiences for the children, that they wanted to share with others and provided a focal point for activity based learning and communication. (Woodcock and Woolner 2008)

The evaluation of Project Spectrum provided three key outcomes

1.) Design recommendations for iterative development; ideas for new modules and links into the national curriculum which have been taken forward into later projects such as Woolner (2007)

2.) An indication of the benefits individual children and their parents gained through experiencing the environment

3.) An assessment of the environment in the school system, and recommendations for the design of future rooms (Figure 5.1)

Summary

This chapter has discussed the evaluation of Project Spectrum, and how this process was informed by the research. The evaluation has shown the benefit of Project Spectrum to the community for whom it was designed through the implementation of the research. The application of the Hexagon-Spindle model has been discussed and how this informed the evaluation of both the environment and the child's experience.

By taking a holistic approach to the creation and delivery of the work, a tailored experience was provided to children which was integrated into their existing schedule of school activities. The value of this was brought out in the testaments of teachers, parents and support staff. In order to provide more quantitive data the evaluation would have benefitted from a greater sample number, but this was not possible within the project resources.

At a wider level Project Spectrum has demonstrated the need for a dedicated, tailored space for children in schools, where they can feel safe and in control of their environment. Such spaces are not provided in all schools in the U.K. though with the investment in Building Schools for the Future (Department for Education and Skills, 2007) could become a priority. This research has demonstrated that the technology to support such spaces is readily available, and that their is grass roots support for this type of work amongst communities.

Chapter 8 - Conclusion

Introduction

The previous chapter discussed the evaluation of Project Spectrum. This final chapter will conclude the research by examining how the aims and objectives have been met and what the contributions to knowledge have been. It discusses the limitations to the research and outlines recommendations for future work in the field. It then briefly details two subsequent projects that have been informed by this research before concluding by summing up the success of Project Spectrum and the research it has generated.

Aims and Objectives

The main aim of the research was to explore the use of interactive media to engage children on the autistic spectrum. In order to achieve this it was first necessary to understand the needs of children with an ASD, and the challenges faced by the communities living and working with them. This was initially achieved through the literature and state of the art reviews (presented in chapters 2 and 3) and supplemented by the research of fellow student Jackson (2009).

This was enriched through a process of community centred design (presented in chapter 4), where members of various communities with relevant expertise were interrogated. This included integrating my practice with target users, and opening up my practice and ideas to allow the tacit knowledge, experience and expertise of others to inform the design process. This process further contributed a more detailed understanding of the user requirements which in turn could be fed back to other communities.

Significantly this process revealed the need for a community based low arousal environment in which the interactive media could be used. This insight led the to the environment being installed in a local school (presented in chapter 5), identified as an institution that was already catering for children with ASD and that understood the need for such an environment. From this, new sets of requirements emerged relating to the use of such an environment in a school (ie academic teaching and learning environment). The community based research also revealed the need for a facilitator who would ideally be someone with whom the children were familiar and comfortable and who would work closely with them.

The state of the art review revealed how emergent interactive technology has provided artists with a new toolset with which to create engaging and participatory experiences for audiences. The reciprocal and interactive nature of these experiences demonstrated their potential for being used within designs for children with ASD, and have been applied in successful projects such as MEDIATE (Creed et al. 2005). Inspired by this and informed by the user requirements, a series of interactive digital media modules were created (presented in chapter 6) that used a computer vision based interface allowing children to engage with them through the movement of their bodies. These modules were delivered within the bespoke school environment, and their use was integrated into the timetable of the children and staff. A facilitator was employed to support this process.

The subsequent evaluation showed the effectiveness of the experiences from the perspective of all stakeholders. Through the application of the Hexagon-Spindle model, each stakeholder is represented within the evaluation and their relationship to the project is contextualised. The testaments of members of several communities including parents, teachers, members of the local authority and project funders commented on the success of the project from their various perspectives. The research has also led to several publications to the academic community, (included in the Appendices), and to new projects within my own design practice.

A design process for community centred design has been developed as part of this research (chapter 3). This model can be applied to future design projects in this field alongside the set of recommendations for environment design published in the Project Spectrum poster (Woolner et al. 2005) and the set of requirements produced for children on the autistic spectrum. The model takes into account the importance of action research, iterative design and reflective practice when designing for this user group, and how this can lead to work such as Project Spectrum which becomes integrated into the community who have informed its design. Placing the designer at the centre of this process, they are tasked with recording and disseminating the tacit knowledge of communities and embedding this knowledge into new artefacts, reflecting on this process and transferring their findings into new work. The research has also shown how the Hexagon-Spindle Model (Woodcock et al. 2008) of educational ergonomics can be applied to the development of work in this field, and can be used within both the design and evaluation phases of a project.

Contributions to knowledge

This research has made the following contributions to knowledge:

1.) A new model for community centred design.

Community centred design is a research process which acknowledges that when designing for a specific user group, decisions are influenced by a wider number of communities than just the immediate users. This is particularly apparent when designing for user groups who are unable to directly express their opinions; in projects which bring together diverse areas of research and practice; and in projects in which various stakeholders require various outcomes of the design. Each of these scenarios was present in Project Spectrum, and it was necessary to create an original model that described this process that could then be offered to practitioners hoping to develop work in similar circumstances.

Community centred design invites the designer to engage with the various communities that will inform his practice through action research, whilst simultaneously employing reflective practice to create meaningful designs that respond to and embed the knowledge he receives from the communities. As part of this process he will actively disseminate knowledge between disparate communities in order to engage with their reflections and opinions on this information.

The designer therefore becomes a conduit for the knowledge that travels between the communities, and manifests designs for the users in response to knowledge he accrues over this time. The final design, whilst still firmly targeted at the end users, assimilates knowledge from the diverse range of communities made available through this active design process.

2.) That environments such as that created during Project Spectrum are a valuable resource in any school, and that they help to meet the needs of certain members of the pupil population. Project Spectrum has illustrated how this can be achieved successfully and affordably, and how the environment can support the use of interactive digital media.

3.) That the role of a trained facilitator is key to the success of working with the media and environment to promote engagement from the child. This person tailors the relationship between child and the activities according to requirements, and ensures a consistent, safe and appropriate experience is had.

4.) Validation of the Hexagon-Spindle Model for the educational domain

5.) A series of requirements for further work in this field, elicited from the community and exemplified in the work produced.

Limitations of the research

1.) The main limitation of this research was the limited resources available for the creation of Project Spectrum. This meant that I alone was responsible for the realisation and installation of the designs produced. This included having to create the environment in the school as well as create all of the digital modules. I was also alone in accessing and building links within the local community to support the project, and it was volunteers from this community who provided much of the support needed in realising the final designs. This stands as testament to the value of community centred design, and shows that by having a stake in the project from its inception, people will take greater ownership and pride in the artefacts produced. Never the less the project could have benefitted from a range of additional professionals to assist with the construction of the environment and the programming of the digital modules.

2.) Whilst the project illustrated the use of computer vision to produce visual and audio stimuli, the requirements elicited also showed a need for tactile experiences for the children. Whilst the environment did support activities to engage children's tactility, these were not part of the original design. Given more time and resources, I would like to have produced tactile objects such as squeeze toys which would link in with the existing PS system.

3.) Whilst other children at the school did use the environment, the evaluation took place with only two children participating for the duration. This was due to only a limited number of children at the school having a diagnosis of ASD, and the limited time available to the facilitator to work with them on a daily basis. Given the resource to employ a full time facilitator and to establish the environment in several schools, the evaluation could be repeated with a larger number of children.

Further research

At present environments and interactive media such as those created for Project Spectrum are not readily available in schools. ICT in schools remains limited to the use of computers at workstations, and the use of software via a mouse and keyboard. It remains to be seen how alternative methods of human computer interaction can be integrated into the school curriculum, adopting technology such as that currently being made popular in homes via the motion sensing devices of the Nintendo Wii and the upcoming Microsoft project Natal and Sony motion tracking games consoles. Further research is needed into the use of such technologies with both mainstream and SEN pupils, for whom distinct applications could be developed.

This research has also identified a need for tailorable pupil centred environments in schools, and has illustrated what the benefits of such a facility can be. In particular such spaces could be of high value to schools who advocate including pupils with SEN including those with ASD. More research is needed into how schools go about creating such spaces within their limited resources, and how they then integrate and support their use within the everyday routine of the school, ensuring that the facility is made available to pupils who will benefit from its use. This includes the need for research into how existing staff can be trained as facilitators for the environment, or whether this role is best served by a dedicated professional.

Further research is also required into the impact of community based research projects on the communities who have informed the design, but have not been involved as users of the finished artefact. For example, following Project Spectrum it would be of value to know the indirect impact that the project has had on the design community who advised during the development phase.

Subsequent projects

Mobile Project Spectrum

Having completed the Project Spectrum evaluation, I produced a mobile version of the system that could be shared with a wider section of the community. The design of this draws on my experiences during the action research, and the recognised need for a consistent setup that can be taken into schools to demonstrate the potential of work in this field. This portable setup fits into the boot of a car, and allows me to travel to schools and work with a range of pupils. It focusses on presenting the interactive modules, and does not offer the benefits of the low arousal environment.

The setup consists of a folding back projection screen and short throw projector. This allows for setting up in more confined spaces and also avoids the children's interactions casting shadows on the screen. A laptop is used to control the modules, and this is connected to a small digital video camera for motion tracking attached to the underside of the screen, as well as a set of speakers and the projector. The system can be setup and calibrated in less than an hour and taken down even more quickly.

My initial evaluation of this system took place at a school specifically for children with communication difficulties such as ASD. Working with staff and pupils, I introduced them to the Project Spectrum modules and ascertained their effectiveness through the comments of staff present at sessions. This is documented in the supporting AV material p.32. Since then, I have used it with other children on the autistic spectrum, and have also had the opportunity to test it with children with other special educational needs (See supporting AV material p.34-37).

The Imaginator

Following the completion of Project Spectrum I was commissioned to create an interactive digital installation to promote child led creativity amongst primary school children. The project was inspired by the Reggio Emilia approach to early years education (Learning and teaching Scotland, 2006).

The design of 'The Imaginator' (Woolner, 2007) drew on my experience during Project Spectrum and built on some of the findings from the research. For example similar technology was used in its design, with the same software being employed in order to create user interfaces that teachers would be able to use simply. A computer vision system was also used, allowing the children to see a live image of themselves within the installation.

The Imaginator was designed specifically for use in schools, and I employed the community centred design process developed during PS, engaging in an iterative design process during which I worked with several schools in order to test and inform the design. This involved introducing the technology and its potential uses to the community and then developing designs based on their feedback. As part of this process, prototype artefacts were left with schools for three days, during which they would use and evaluate the design, and feedback their findings.

The Imaginator evaluation was based on the feedback of school staff who reported that "whilst each school had approached the project differently, all the teachers involved felt that it had been of high value both to them and their children. Of particular note was that it enabled shyer and less able children to participate in activities with their peer group." This feedback suggested to me that some of the engagement benefits of Project Spectrum were also apparent in the Imaginator. Some of the teachers also commented on how its simplicity of use had "built their own confidence with I.T., and given them access to equipment they would not otherwise have used. Working with the artist team had not only given teachers access to new ways of approaching technology driven art projects, but also given them the opportunity to stand back and observe how their children worked creatively. They also noted that the creative behaviour of some children would change when in the teacher's presence." This feedback illustrated to me how a community centred design approach can benefit both designer and user, revealing unforeseen benefits to design and allowing users to take ownership and inspiration from the artefacts produced.

A fundamental part of the Imaginator's design was allowing pupils rather than the designer to create and select visual and audio media to be included in the installation. This was done by providing them with digital cameras and sound recorders to author media with, and working with artists to learn how to use them. Having loaded the media into the program with the help of a teacher, they were then able to manipulate these images and combine them with the computer vision system to create their own unique digital content, and present in a way that they have chosen. This child led authorship was missing from Project Spectrum, having not been prioritised in the requirements, but was a welcome addition to my portfolio of work and proved popular when testing the Imaginator with children on the autistic spectrum. In particular they enjoyed being able to control the media using a series of buttons, knobs and sliders.

This work was later developed to include Nintendo Wii technology (the wiiMaginator) allowing children to manipulate media and control modules using the handheld wireless controller. This has subsequently led to several projects that have explored the use of gaming technology to engage school pupils and teach them new skills.

<u>Conclusion</u>

The primary aim of this research was to explore the use of interactive digital media with children on the autistic spectrum. In doing this a range of theory and practice has been developed which have become the basis for my continued interest and practice in this field.

Collaborating on Project Spectrum was a challenging and ultimately rewarding experience, especially having had the opportunity to realise my designs and see them used within a mainstream school. Working with fellow professionals and members of the community within both a funded project and academic context taught me about the complexities of working with a variety of stakeholders. This experience has furnished me with the skills and confidence to continue working with children and schools to develop new and exciting projects, which continue to explore the potential of technology to engage pupils, particularly those with additional educational needs.

My work on Project Spectrum has led to me being invited to consult with schools catering for pupils with ASD on their use of sensory environments, and how to meet the sensory needs of their pupils. I have also been contacted by several individuals from overseas who have become aware of the research and are interested in implementing similar ideas in their own design projects. In addition the academic pursuit of this research has led to several publications inspired by the work of Project Spectrum in the fields of design, ergonomics and autism. The publication of this research and Jackson's study of the sensory requirements of the children provide additional support to these papers, and pave the way for future studies in this field.

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Appendices

Designing a tailorable environment for children with autistic spectrum disorders,

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Abstract

The prevalence rate of individuals with an autistic spectrum disorder (ASD) is estimated to be approximately 91/10,000 in the UK. Children with ASD may vary in the extent and type of symptoms they display, but all have the triad of impairments in social interaction, communication and restricted patterns of behaviour. Given that research suggests that early intervention can maximize the potential of a child with an ASD and each child has a unique profile, there is a clear need to develop systems that are not only of benefit and pleasure, but that are also tailorable to individual characteristics. Also, with the wider inclusion of children with special educational needs in mainstream education, there is an additional requirement that such systems should not just be tailorable to a wide range of children, but affordable and robust enough to form part of the every day school environment. This paper outlines the research undertaken in understanding the characteristics of children with ASD and how such an understanding has led to the development of a low cost, multimedia environment for mainstream schools.

Keywords: Children, user centred design, school design

1. Introduction

Wing and Gould [1] suggested that the expression of autism amongst children was diverse enough to warrant classification as a continuum and when taking into account Asperger Disorder as a more expansive conceptualization of autism, the notion of the autistic spectrum was developed. Individuals with an autistic spectrum disorder (ASD) all display the 'triad of impairments' in:

social interaction e.g. appearing aloof and withdrawing from interaction, inappropriate interaction/appearing 'odd', lack of willingness to share experiences and lack of social or emotional reciprocity

communication e.g. delay in speech onset, inability to engage in conversation, stereotyped, repetitive use of language, use of and understanding of nonverbal communication such as facial expression and body language

restricted, repetitive and stereotypical patterns of behaviour, interests, and activities e.g. preoccupation with one or more stereotypes, restrictive patterns of interest, inflexible adherence to routines and rituals, preoccupation with parts of objects.

The most effective time to achieve break through in these patterns is in early childhood. However, as children may exhibit different patterns of hyper and hypo sensitivity in each of the senses, and, in most cases be unable to communicate their feelings, it is difficult to develop effective intervention programmes.

Approaches to the development of environments to engage children with ASD range from Snoezelen [2] environments to computer applications and robotics [3], through to multimedia environments such as MEDIATE [4]. Evaluation of the effectiveness of any of these is difficult due to the nature of children with ASD.

'Project Spectrum' had three aims

to take a user centered approach to the development of an environment, based on an understanding of the needs of children with ASD

to provide a polysensory environment that could be tailored to meet the needs of individual children

to develop a means of evaluating this and other systems.

This paper will address each of these

2. Understanding the needs of children with ASD

Ideally we would have liked to have worked directly with children in developing requirements for the environment, this was not possible because, firstly, it is very difficult to gather requirements from young children in general; secondly, most of this particular user group would not be able to communicate with us; and thirdly, working closely with a small set of children may not provide the representative sample required. Instead we adopted a 'design for users' approach.

This was based on an understanding of the end user population through personal experience, observation, semi-structured interviews (with parents and, where possible children) and questionnaires. Jackson took the lead in this part of the research, and has first hand experience of the problems of children with ASD, and being a well known commentator in this area had an extensive network to draw on.

Firstly a web-based questionnaire was used to ascertain the profile of children with ASD, their sensory preferences and previous experience of multi-sensory rooms. From the 500 responses we established a profile of the intended user group and the levels of tailorability needed to accommodate most of the children (see Table 1).

These findings were corroborated through observation of eight children from different parts of the spectrum, playing in a traditional multi-sensory environment.. This provided information on the effects of environmental differences on the behaviour of individual children (such as different types of music and lighting effects). Recognizing the need for depth and meaning when interpreting data, 25 semi-structured interviews were conducted; 10 with teenagers with Asperger's Syndrome or High Functioning Autism and 15 with parents of children on various places of the autistic spectrum.

Lastly, in order to build a rich picture of the life of a child with ASD for the designer, and contextualise the system, detailed descriptions of a 'day in the life' of 5 children were created to show how ASD affects each child and where an interactive environment might fit into daily routines.

Rather than simply relying on the data provided from the social research, the designer, Woolner, gathered first hand experiences through associations with special and main stream schools where he worked alongside the developers of other systems and their users.

2.1. Specimen results

We believe that we have gathered one of the most detailed pictures of children with autism that will be of great value and practical assistance to designers, and the subject of forthcoming papers. Summarising these results reduces the complexity of the problems and the richness of the data .

Table 1

Summary of results from the Internet survey

Lower functioning children

Higher functioning/ Aspergers

Prefer

Red

Blue

Round shapes

Circular shapes

Nursery rhymes, meditation music

Rock/pop music

Smooth, soft and downy textures

Smooth soft and downy textures

Mirrors

Projected light effects

Soft play areas

Soft play areas

Sound, light equipment
Sound, light equipment
Dislike
Sticky, slimy or prickly textures
Sticky, prickly, slimy, rough textures

Loud noises and specific noises
Loud noises and specific noises

Sensitivities to smell
Smells, certain lighting

Interaction and engagement
Interaction with others

Bearing this in mind, Table 1 provides an edited version of results from the Internet survey, showing the extent of tailorability the system will need if it is to accommodate children at each end of the spectrum. This also shows, that children with ASD have sensory issues in terms of olfactory, tactile, vestibular (movement), auditory and visual input. If the final system is to facilitate sensory cohesion then each of these areas has to be addressed and opportunity provided to gradually introduce some dislikes in order to decrease sensitivities.
Observations made in traditional, multi sensory environments showed that although some children derived benefit from these, displaying both enjoyment and relaxation, there were noticeable differential effects caused for example by lighting, on those with Asperger's Syndrome and those with 'classic' autism.
These observations highlighted the complexity of designing for this group. For, example, some parents reported that although their children enjoyed the experience, they became over stimulated, hyperactive and aggressive for the rest of the day. A balance is therefore needed whereby the system encourages interaction with the world, but does not over-stimulate. We cannot simply design a system that children

will enjoy, but have to consider the short, medium and long term effects as well. Given that each child has their own profile of preferences which maybe based on their hyper and hypo sensitivities and crossovers between the sensory input, this is a challenge.
Most children became calmer and more relaxed from tactile input such as immersion in the ball pool, being squashed under soft bean bags or spun around in a hammock. We may conclude that although tailorable digital media may be useful, there is also a need for concrete, tangible objects to be used, perhaps at the start of the sessions for relaxation. This might allow the children to be more focused and able to work and interact with the visual and auditory stimuli offered to them.

From the interviews with parents the following themes emerged: the relationship between colour, mood and behaviour; the prevalence of spinning (self or objects) across the spectrum; differences and difficulties in movement and co-ordination; the importance of control and predictability for the children (to provide feelings of security); ethics and identity were also major themes.
However, how these become manifest is dependent on the child. For example, one child may like to spin small wheels, and another spin himself. For one child we may wish to increase certain behaviour, for another reduce it. Such differences point to the need for a tailorable system that can not only be adjusted to each child, but which can allow the child to increase their interactions with it.

2.2. Macro-level requirements

Whilst the requirements for the range of tailorability needed to accommodate children at all places on the spectrum emerged from focused activities with parents, children and carers, the macro level requirements emerged more slowly through discussions and working with schools and other members of the community.
Different types of installations (or environments) were considered - based around a computer, location independent, in part of a room, or a room in a school or leisure centre. This was coupled to the need to make the environment as accessible as possible - limiting its complexity, without compromising its functionality and tailorability.

By positioning our environment in mainstream schools, we believe that we will benefit the maximum number of children, as it is now UK policy to include many children with SEN in mainstream schools. This means that all children will have access to an environment that can be adjusted to their own needs and preferences by members of the teaching staff or their care assistants. This decision obviously had ramifications for the room and furniture design as discussed in the following sections.

Providing a tailorable environment

The requirements were presented to the designer as tables, case studies, in discussions and visits to other systems. It was found difficult to provide a rich enough description of the requirements through formal methods or design checklists.

Initially this led to a series of poorly integrated early prototypes, which were technology based, stand-alones. For example, the discovery that a lot of children liked spinning, red, circular shapes, and had poor eye-hand co-ordination led to a module in which a series of virtual cogs could be interlinked and spun in different directions. Although this, and similar ideas enabled Woolner to produce initial prototypes, this bottom up approach failed to create the immersive environment. This approach prevailed for much of the first year, until the macro level requirements emerged, through a consideration of how the space would be accessed (see above), culminating in a 'day in the life' type poster which became a blue print for the design of the modules and how they would accessed in the school environment.

4. Construction and implementation

Project Spectrum at its most basic is an empty, low sensory room in a school that can provide refuge and host tailorable experiences away from mainstream activity. Into this material (digital and tangible) can be added that will help children to become more engaged with the world.

Such an approach is not novel. However, we believe it embodies the requirements needed. Positioning and building the room in a school means that it will be accessible by all children (not just those who can be driven to it), will be robust, achievable

within school budgets, easy to use (by teachers and carers, not dedicated technicians), adaptable to everyday spaces found in schools, provide opportunities to integrate with the school curriculum and to invite other children into the space.
Such an environment has been constructed in a local primary school and is now forming the base room of one child with ASD.

Obviously we would have liked to be able to design and build a room to our own specifications, however, in terms of ecological validity being provided with a typical classroom, and overcoming its limitations showed that it should be possible to do this in any school.

The room provided was 6m square, has three large windows that open onto a playground which is very noisy during break times. It had a high ceiling, lit by strip fluorescent lighting. The floor was covered with an aging nylon carpet, the walls painted beige and covered in posters, pin up boards, black boards and an old interactive whiteboard.

Figure 1
The screen as mirror

Woolner converted this to a low stimulation sensory room (see Figure 1) by stripping and repainting the walls white and replacing the floor with natural marmoleum. Blinds were made from white blackout material to block out light. The strip lighting was replaced with daylight bulbs and an LED lighting system installed to allow for control of the ambient light colour. Furniture was minimal and standard, and organised in such a way as to allow individual and paired working, both in the context of the classroom and when participating in the interactive modules. The room now includes a desk, soft play area and rocking chair.

Although the school has been generous with its space and the help and tolerance we have received, working to within the regulations for school buildings means that we have not been able to erect screens and concern has been expressed about the blinds and closed door in the room. Also, the room itself was initially perceived as sterile, and is acoustically problematic. Significant investment would be required to correct the acoustics in the room to the highest standards.

To accommodate the polysensory environment a custom projection screen was installed along with a data projector, positioned to allow for interaction with digital content. Two cameras, speakers and a computer system were installed to deliver the digital content. Figure 1 shows the screen acting as mirror to allow the user to become used to seeing himself and interacting with others on the screen.

To date, nine modules have been developed based on the requirements. Each of these can be tailored to allow lesser or greater interaction. In all cases the modules have been kept as simple as possible so that there is an obvious and direct correlation between the actions made by the child

Figure 2

Using movement to control abstract representations

and what appears on the screen. The opening module, as shown in Figure 1, merely gets the child used to the environment, and seeing themselves on the screen. In Figure 1, the carer is also shown as a precursor to introducing later modules that will require levels of social interaction.

Figure 2 shows a later module based around enhancing movement and co-ordination. Earlier versions of the module (based on a kaleidoscope of faces) were too complicated and bewildering. In this example, movement of the arm and body triggers changes to the pattern being displayed.

All modules have been installed in the system and are currently being tested in a six week evaluation programme, at the moment based on a single user.

5. Evaluation

Evaluation of therapeutic environments for this particular user group is difficult for several reasons. Firstly, because the children are not able to tell you what they feel; secondly because each module might effect the user in a different way; thirdly, because any effects of working in the environment may be swamped (in the immediate, short and long term) by extraneous variables. For example, sensory experiences encountered on the journey to school may be overwhelming, medication and other therapies might change, personal issues might lead to temporary withdrawal from all forms of interaction.

Any evaluation process has to take account of these factors. As mentioned in Section 4 we are currently in the early stages of evaluation. This is the second pilot evaluation. The first provided a technical trial - to establish sound and visual quality. This also provided first hand experience of difficulties in evaluation as one of the participants dropped out because of peer pressure, and our main user was 'uncooperative'. However, we have developed a formative, illuminative evaluation strategy which takes into account base line behavioural measures, contextualisation of the experience and the degree of engagement with the specific module. Where possible the feelings of the user will also be recorded. In summary,

base line behaviour will be compared before and after the trial using ATEC [5]. This is filled in by parents

a simple checklist for use by the carer, has been developed by Jackson to measure changes in behaviour before and after each module. This will be transferable to other programmes and environments

a diary is kept by the carer and where possible, the user. This includes two parts - one to record the interaction with the module and the second to provide more general information which may effect the session video analysis to provide quantitative data on levels of engagement with the material.

Once analysed, the results will be fed back to the designers for the iterative development of the modules and the relevant school authorities. We will also reflect on and revise the evaluation strategy adopted.

6. Conclusions

An overview has been provided of the research undertaken by Project Spectrum in developing a tailorable environment to nurture the engagement of children with Autistic Spectrum Disorders.

The long term contributions of the project will be in the provision of a method for gathering the requirements from children and their carers, the requirements themselves which may be used to develop other environments, the evaluation methodology and the experience built up by the team.

The project believes that the overall approach, i.e. the development of the environment, positioned in the school, which provides not only a safe haven for children with ASD, but that can be tailored to meet individual and curricular needs will be crucial to enabling children with ASD to integrate in main school environments.

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Children with Autistic Spectrum Disorders suffer from varying degrees of qualitative impairments in social interaction, communication and restricted patterns of behaviour. This is accompanied by hyper- and hypo-sensitivities in each of the senses. Given that each child seems to have a unique profile, there is a clear need to develop systems that may not only be of benefit and pleasure to them, but that are also tailorable to their individual characteristics. This paper outlines the research undertaken in understanding the characteristics of children with ASD and how such an understanding has led to the development of a low cost, multimedia environment for mainstream schools.

Introduction

In Georgiou et al (2003) we outlined our approach to the design of polysensory environments for children with autistic spectrum disorders (ASD). We hope to develop an environment, incorporating interactive media, that can be tailored to meet the needs of individual children and facilitate their engagement with their surroundings and other people. Central to this, is that we should not let technology lead the research and development, but should focus on the needs of the users – the children, their parents and carers. This paper commences by briefly summarising the nature of autism, moving onto requirements elicitation and presenting specimen results, before concluding with an illustration of how these have informed system design.

Introduction to Autistic Spectrum Disorders

The American Psychiatric Association (DSM – IV, 1994) characterise Autistic Spectrum Disorders by qualitative impairment in: social interaction e.g. use of nonverbal behaviour, failure to develop peer relationships, lack of willingness to share experiences and lack of social or emotional reciprocity communication e.g. delay in speech onset, inability to engage in conversation, stereotyped, repetitive use of language, inability to engage in make believe or social imitative play and restricted, repetitive and stereotypical patterns of behaviour, interests, and activities e.g. preoccupation with one or more stereotypes, restrictive patterns of interest, inflexible adherence to routines and rituals, preoccupation with parts of objects.

With an onset before three years of age, the most effective time to mediate a break through in these patterns is in early childhood. However, given that symptoms may vary in both their pattern and extremity from one individual to another, and that children with ASD may not be able to articulate their needs, or even have their needs correctly identified, it is very hard to adopt a user centred approach to system design, although one is clearly needed.

Requirements Elicitation

User centred design can be undertaken using three different approaches (Eason, 1992); namely design for users, by users or with users. Given the nature of the user group we relied primarily on the first of these, namely design for users, based on an understanding of the end user population through personal experience, observation, semi structured interviews (with parents and, where possible children) and questionnaires. Where possible iterative design may be undertaken in conjunction with users.

A web-based questionnaire was used to ascertain the profile of children with ASD, their sensory preferences and previous experience of multi-sensory rooms. From the 500 responses we established a profile of the intended user group and the levels of tailorability needed to accommodate most of the children (see Table 1). These findings were corroborated through observation of eight children from different parts of the spectrum, playing in traditional environments. To add depth to the data, 25 semi structured interviews were conducted; 10 with teenagers with Asperger's Syndrome or High Functioning Autism and 15 with parents of children on various places of the autistic spectrum. Also, in order to build a rich picture of the life of a child with ASD for the designer, and contextualise the system, detailed descriptions of a 'day in the life' of 5 children were created to show how ASD affects each child and how the use of an interactive environment could be of benefit.

As well as Jackson collecting these materials and presenting them in summary tables, Woolner (the designer) felt the need to immerse himself at a deeper level. This was in order to develop a working relationship with the user group, derive his own research material and develop his own knowledge of the community. He felt it was impossible, even when working in collaboration with an expert, to act solely from the information and direction received from others. Woolner therefore worked as artist-in-residence at a special needs school, provided technical support on similar projects and forged links with local schools.

Overview of requirements

From Table 1 it can be concluded that children with an ASD have sensory issues in terms of olfactory, tactile, vestibular (movement), auditory and visual input. If the final system is to facilitate sensory integration then each of these areas has to be addressed and opportunity provided to gradually introduce some dislikes in order to decrease sensitivities.

Observations made in traditional, multi sensory environments showed that some children derived benefit from these, displaying both enjoyment and relaxation. However there were noticeable differential effects caused for example by lighting, on those with Asperger's Syndrome and those with 'classic' autism. Some parents reported that although their

Table 1. Specimen results from the quantitative data

Lower functioning children

Higher functioning/ Aspergers

Preferences

Red

Blue

Round shapes

Circular shapes

Nursery rhymes, meditation music

Rock/pop music

Smooth, soft and downy textures

Smooth soft and downy textures

Mirrors

Projected light effects

Soft play areas

Soft play areas

Sound/light equipment

Sound/light equipment

Dislikes

Sticky, slimy or prickly textures

Sticky, prickly, slimy, rough textures

Loud noises and specific noises

Loud noises and specific noises

Sensitivities to smell
Smells, certain lighting

Interaction, engagement with others
Interaction with others

children enjoyed the experience they became overstimulated, hyperactive and aggressive for the rest of the day. However all children became visibly calm and more relaxed from tactile input such as immersion in the ball pool, being squashed under soft bean bags or spun around in an encasing hammock. We may conclude from this that although tailorable digital media may be useful, there is also a need for concrete, tangible objects to be used, perhaps at the start of the sessions for relaxation. This might allow the children to be more focused and able to work and interact with the visual and auditory stimuli offered to them.

From the interviews with parents the following themes emerged:
The association of colour with mood and behaviour
Widespread spinning behaviour through all the group – of either self or objects
Differences in movement and co-ordination. A high proportion of the higher functioning children had coordination problems, whereas children on the lower end of the spectrum were seen as agile and active, but with their own distinct pattern of movement and needed to repeat certain movements in each environment.
The need for an environment over which the children could exhibit some control. Predictability made the children feel secure and reduced anxiety. An environment in which the child knows what is to happen next and possibly author such changes themselves, can empower the child and give them a feeling of security
Interaction with others was a widespread problem

The interpretation of these is dependent on the child; e.g. preference for 'spinning' can have a different meaning to each child. Some children may like to spin small wheels on a car whilst other may like to spin themselves. Additionally, from an ethical perspective should we be reinforcing a behaviour that may be viewed as unwanted or abnormal in certain circumstances? The results confirmed the need for an environment that is sufficiently tailorable and adaptable to accommodate and benefit children at all places on the spectrum.

Communicating requirements to the designer

The requirements were presented in a number of ways to the research team - reports, summary tables, case studies and discussions. This approach was adopted over formal methods because of the complexity and level of detail that needed to be conveyed to the designer, before he could understand the complexity of the subject area. Additionally there was little enthusiasm for producing or receiving formal specifications once material been presented in other ways.

Developing the modules

The discussion about requirements and the need to feed these quickly into system design modules led initially to a series of poorly integrated early prototypes, which were technology based, stand alones. For example, the discovery that a lot of children liked spinning, red, circular shapes, and had poor eye hand co-ordination led to the production of a simple module in which a series of virtual cogs could be interlinked and spun in different directions. Although this, and similar ideas enabled Woolner to produce initial prototypes, this bottom up approach failed to create the immersive environment we required.

The 'breakthrough' for the project came after 18 months when during a face-to-face, brainstorming session we stepped back from the immediate user requirements to just consider how we imagined children would use the space. We all agreed that Project Spectrum at its most basic was an empty room in, for example, a school, that could provide refuge and tailorable experiences away from mainstream activity. Into this we could add material that would help children to become more engaged with the world. Positioning our space in this context generated further requirements related to the number of users, timetabling, affordability and usage.

It may be argued that this approach is not novel – for example there are, Snoezlen environments and soft and multimedia play areas. However, in some cases use of these is restricted to parents who can bring their child to the installation; the installation is expensive, large and requires skilled technicians to operate it; there has been little evaluation of the benefits the children derive from being in the environments; and technology led projects may not be at all intuitive in terms of their cause and effects (so confusing the children), and many cannot be tailored to benefit children on different places on the spectrum. If our project is to make a contribution it will be in identifying these areas as ones that can be addressed through the creation of tailorable, affordable rooms located in mainstream schools, that are accessible to all children.

Building the environment

With the above aims in mind, we located a primary school in Birmingham, which had a room we could 'make over'. Obviously we would have liked to be able to design and build a room to our own specifications, however, in terms of ecological validity being provided with a typical classroom, and overcoming its limitations showed that it should be possible to do this in any school.

The room used we took over is approximately 6m square, has three large windows that open onto a playground which is noisy during break times. It has a high ceiling, lit by strip fluorescent lighting. The floor was covered with an ageing nylon carpet, the walls painted beige and covered in posters, pin up boards, black boards and an old interactive whiteboard.

This was converted by Woolner over the summer into a low stimulation sensory room (see Figure 1). The walls were stripped and repainted white, the floor replaced with natural marmoleum. Blinds were made from white blackout material to block out light and noise from outside. A custom projection screen was built and installed along with a data projector, positioned to allow for interaction with digital content.

Two cameras, speakers and a computer system were installed to deliver the digital content. The strip lighting was removed and replaced with daylight bulbs and an LED lighting system also installed to allow for control of the ambient light colour. Furniture was minimal and standard, and organised in such a way as to allow individual and paired working, both in the context of the classroom and when participating in the interactive modules.

Figure 1. Interacting in the room

Figure 2. Movement and colour

All the digital modules (such as the one shown in Figure 2) have been developed according to the researched requirements of the children. They are designed to add to the palette of activities a teacher or carer may use to engage with the child. Based around the senses, the modules engage the children through vision, sound, movement and touch. The digital system allows the child to receive immediate feedback from their actions, creating a cycle of interaction that empowers the individual through an immersive control system. The software that controls the system has been designed to be simple and intuitive with a small learning curve, so that teachers can start using it immediately, without technical support.

Future work

We are currently iteratively developing our environment – bringing in different lighting solutions and soft furnishings. The room is used as a base room for one child and his support worker and we are introducing him to the research team, experimental protocols (cameras etc) and the modules. In 2006 we will invite more children into the space and introduce video conferencing to show what is happening in lessons. Our evaluation strategy is likewise evolving. We still hope to show engagement and pleasure, but have quickly realised that the everyday problems faced by these children will overwhelm our results.

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Designing polysensory rooms for children with Autistic Spectrum Disorders

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Abstract

It is the intention of the UK government to make educational provision in mainstream schools, for children with special educational needs. One group of children included in this are those on the autistic spectrum. With varying degrees of qualitative impairment in social interaction, communication and restricted patterns of behaviour, accompanied by hyper- and hypo-sensitivities, there is a need to develop a low cost, tailorable environment that can be positioned in main streams schools, without placing an undue burden on technical and human resources. This paper provides an overview of the design of such an environment from requirements specification, concept and detail design stages, to realisation and evaluation of a prototype version, located in a primary school.

Introduction

Children with autistic spectrum disorders suffer from qualitative impairment in:

social interaction e.g. use of nonverbal behaviour, failure to develop peer relationships, lack of willingness to share experiences and lack of social or emotional reciprocity

communication e.g. delay in speech onset, inability to engage in conversation, stereotyped, repetitive use of language, inability to engage in make believe or social imitative play and restricted, repetitive and stereotypical patterns of behaviour, interests, and activities e.g. preoccupation with one or more stereotypes, restrictive patterns of interest, inflexible adherence to routines and rituals, preoccupation with parts of objects.

However, these impairments vary in type and severity from one child to another which means that no one child is the same as another, so one design solution will not meet the needs of the whole group. Additionally, in the most extreme cases, not only will the child not be able to say what their needs are, it may also be difficult for parents and carers to deduce the hypo and hypersensitivities, without extensive, first hand knowledge of the child.

With increases in the number of children diagnosed with special educational needs in general and autism in particular, and a rise in the number who need to be accommodated in mainstream education, there is a clear need for the development of an environment, pace or system, that can be tailored to match the needs of the children who will use it. This paper outlines the development of one such environment, Project Spectrum.

Aims and objectives

The aim of the three year, AHRC funded project, was to develop a polysensory environment which would nurture the engagement of children with autistic spectrum disorders (ASD). It had the following objectives

to develop a generic requirement elicitation process that could be used by the project and then others to discover the needs of children with ASD

to use the requirements to inform the development of a polysensory environment to nurture the engagement of children with ASD

to develop a generic evaluation method that could assess the extent to which the environment nurtured the engagement of the children. The evaluation method would also be used by others to evaluate environments seeking the same outcome

Requirements Elicitation

Given the nature of the user group we adopted a user centred approach to design which relied primarily on design for users, basing our design on an in depth understanding of the end user population obtained through personal experience, observation, semi structured interviews (with parents and, where possible children) and questionnaires.

In order to understand more about the range of the user group we were designing for we developed a web-based questionnaire was used to ascertain the profile of children with ASD, their sensory preferences and previous experience of multi-sensory rooms. From the 500 responses we established a profile of the intended user group and the levels of tailorability needed to accommodate most of the children. The responses were classified into two groups relating to those at the higher and lower end of the spectrum. Those at the lower end of the spectrum having the severest forms of autism with limited communication skills and little engagement. The findings were Corroborated through 25 semi structured interviews; 10 with teenagers with Asperger's Syndrome or High Functioning Autism and 15 with parents of children on various places of the autistic spectrum.

Enriched by 'day in the life' studies with 5 children in order to build up a picture of how autism pervades all aspects of family life, and to determine the context in which any environment we designed would be placed

Contextualised by an observational study of eight children on different parts of the spectrum, playing in multi stimulus environments

In spite of this information the designer still felt the need to immerse himself at a deeper level with the user group, to develop a working relationship with the children. He therefore worked as artist-in-residence at a special needs school, providing technical support on similar projects and forging links with local schools.

Overview of requirements

An overview of the requirements has previously been presented in Woodcock et al (2006). To summarise, children with an ASD have sensory issues in terms of olfactory, tactile, vestibular (movement), auditory and visual input. If the final system is to facilitate sensory integration and nurture engagement then each of these areas has to be addressed and opportunities provided to gradually introduce some known dislikes in order to decrease sensitivities. Within the limiations of a three year project we have chosen not to address olfactory sensitivities, but have concentrated on developing a polysensory system that will address visual, auditory, tactile and co-ordination issues.

Observations made in traditional, multi sensory environments showed that some children derived benefit from these, displaying both enjoyment and relaxation. However there were noticeable differential effects caused for example by lighting, on those with Asperger's Syndrome and those with 'classic' autism. This indicates the need for careful control of the items added to the environment, and the need for tailorability within them (for example coloured filters to project different coloured lighting for children with different sensitivities)
Additionally some parents reported that although their children enjoyed the experience they became overstimulated, hyperactive and aggressive for the rest of the day. Clearly, interaction needs to be managed in a controlled way and the short and long term effects of exposure to environments (or preferable, individual items) measured.

Given that all children became visibly calm and more relaxed from tactile input such as immersion in the ball pool, being squashed under soft bean bags or spun around in an encasing hammock, we my also conclude that although a tailorable digital environment may be useful, there is also a need for concrete, tangible objects to be used for relaxation. This might allow the children to be more focused and able to work and interact with the visual and auditory stimuli offered to them.

From the interviews with parents the following themes emerged:
The association of colour with mood and behaviour
Widespread spinning behaviour through all the group – of either self or objects
Differences in movement and co-ordination. A high proportion of the higher functioning children had coordination problems, whereas children on the lower end

of the spectrum were seen as agile and active, but with their own distinct pattern of movement and needed to repeat certain movements in each environment.
The need for an environment over which the children could exhibit some control. An environment in which the child knows what is to happen next and possibly author such changes themselves, can empower the child and give them a feeling of security
Predictability to make the child feel secure and reduced anxiety.
Interaction with others was a widespread problem

The interpretation of these is dependent on the child; e.g. preference for 'spinning'. Some children may like to spin small wheels on a car whilst other may like to spin themselves. The results confirmed the need for an environment that is sufficiently tailorable and adaptable to accommodate and benefit children at all places on the spectrum.

The logical extension of this, is that we are designing an environment that can be tailored to meet the needs of one child at a time, rather than a 'play area' for more than one child, because what one child may like, another may abhor. Additionally, given that we are developing an environment of immense talorability, the system settings may have to be adjusted by the carer or teacher based on an understanding of any particular child. For example, from the quantitative analysis we may know that most of the children at the lower end of the Spectrum prefer red, but there may be a substantial minority who will not be able to tolerate any instance of this colour.

Communicating requirements to the designer

The requirements were presented in a number of ways to the research team - reports, summary tables, case studies and discussions. This approach was adopted over formal methods because of the complexity and level of detail that needed to be conveyed to the designer, before he could understand the complexity of the subject area.

Contextualising and positioning the project

At the start of the project, the team did not have any fixed ideas about the type of system or environment that was going to be developed, other than that it would have some digital content. Existing environments, were seen as problematic in so far as :
They provided limited tailorabilty
Contained items of untested usefulness in nurturing the engagement of autistic children
Were developed as installations in dedicated environments, requiring dedicated high end machines and technical support
Could not be visited easily by a lot of children with ASD. Therefore could not be used on a daily basis.

In contrast we wanted a system that was
easily tailorable to the specific needs of a range of children (for example by importing favourite images and music),
which could be visited repeatedly by children so they could build on their experiences and could form part of a routine,
which would be simple to operate
measurable – so that we could see whether it was benefiting the child

After much debate Project Spectrum was designed to be located in mainstream primary or secondary schools, in line with UK government guidelines for more inclusive education. This generated additional requirements, which at a higher level, included affordability and he need to provide links to the national curriculum. So, at its simplest, Project Spectrum became a low sensory classroom, from which all children (whether on the autistic spectrum or not) could derive benefit. The concept idea for the room is shown in Figure 1.

The room consists of private and public spaces for individual and group activities, a tactile and reflective and an interactive area. We are in the process of developing a set of guidelines for schools wishing to adapt a classroom in this manner. We have been fortunate in developing a collaborative agreement with a local primary school, who had a classroom which we could 'make over' as part of the project, thereby creating a classroom for initially one child with ASD in the school.

This is now becoming a more central resource, with other children with ASD using the facilities during and hopefully after school
Obviously we would have liked to be able to design and build a room to our own specifications, however, in terms of ecological validity being provided with a typical classroom, and overcoming its limitations showed that it should be possible to do this in any school.

The room used we took over is approximately 6m square, has three large windows that open onto a playground which is noisy during break times. It has a high ceiling, lit by strip fluorescent lighting. The floor was covered with an ageing nylon carpet, the walls painted beige and covered in posters, pin up boards, black boards and an old interactive whiteboard.

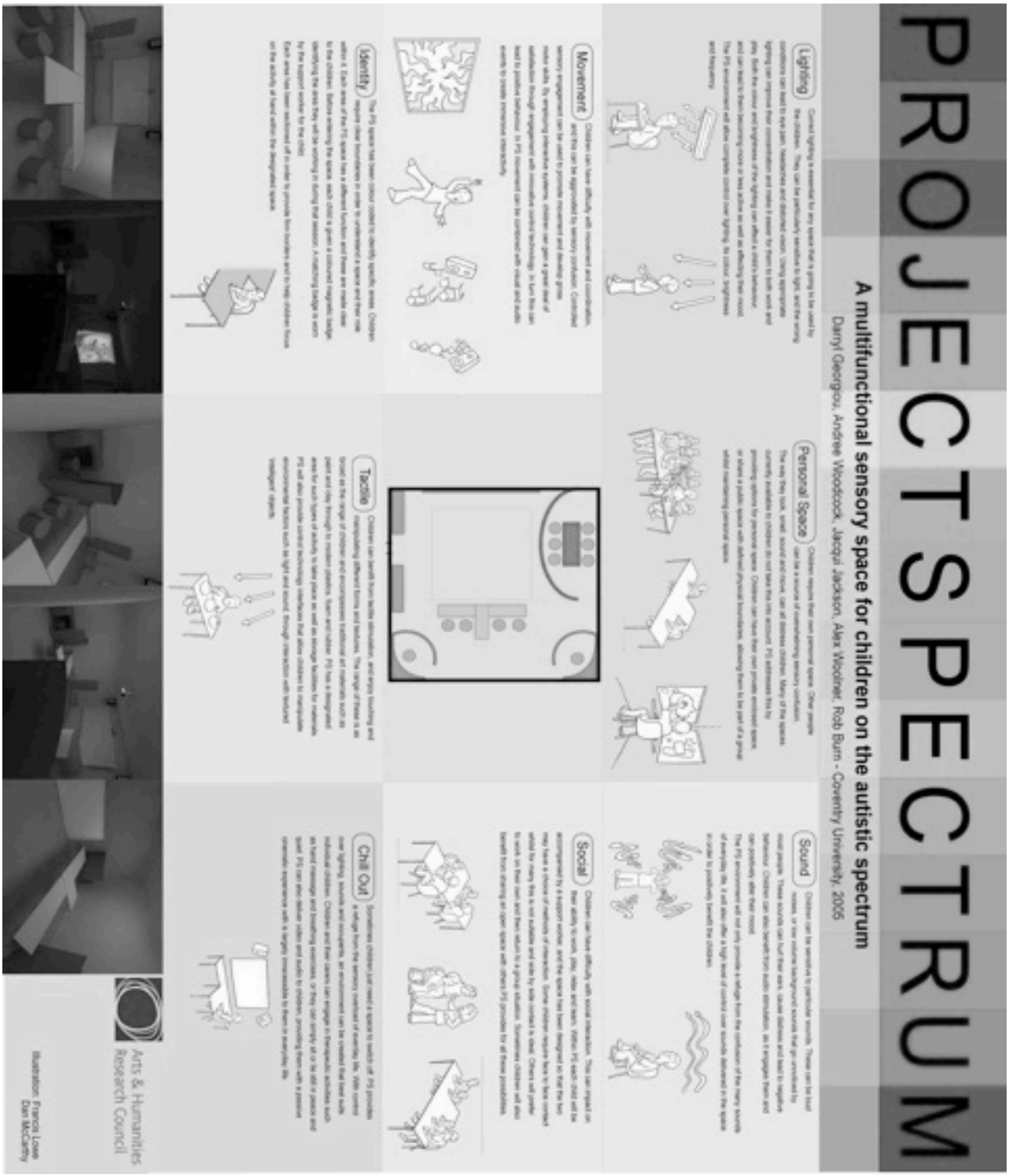

Figure 1 : The PS concept

This was converted by Woolner over the summer into a low stimulation sensory room (see Figure 2). The walls were stripped and repainted white, the floor replaced with natural marmoleum. Blinds were made from white blackout material to block out light and noise from outside. A custom projection screen was built and installed along with a data projector, positioned to allow for interaction with digital content. Two cameras, speakers and a computer system were installed to deliver the digital content. The strip lighting was removed and replaced with daylight bulbs and an LED lighting system also installed to allow for control of the ambient light colour. Furniture was minimal and standard, and organised in such a way as to allow individual and paired working, both in the context of the classroom and when participating in the interactive modules.

Obviously there have been limitations as to what we could achieve. For example, we have not been able to put in a false ceiling, or fully block out the sound from the playground which makes the acoustic environment suboptimal. We are still waiting for the furniture to arrive from the Local Education Authority (LEA), which was ordered, not as part of this project but as part of the school's contract to the pupil. It was our original intention to provide screens to close over private and public areas, but we have not been able to put these in the room, because of LEA restrictions, likewise we are not allowed to close the door to the room

As well as providing a learning environment, the room also provides space for a series of interactive modules developed to meet the requirements of children with ASD.

Figure 2: Classroom makeover

The interactive modules

The modules have been designed to add to the palette of activities a teacher or carer may use to engage with the child. Based around the senses, the modules engage the children through vision, sound, movement and touch. The digital system allows the child to receive immediate feedback from their actions, creating a cycle of interaction that empowers the individual through an immersive control system. The software that controls the system has been designed to be simple and intuitive with a small learning curve, so that teachers and carers can start using it immediately, without technical support. A summary of the modules being developed is shown in Table 1.

Evaluation

We are currently evaluating the room and the modules with three primary school children at different places on the autistic spectrum. Each module will be tested over a period of 3 -4 days, for 15 minutes where possible. The evaluation will be both formative and illuminative, providing information about the children and for the redesign of the modules. The evaluation will include

Initial benchmarking of sensory abilities

Diary to record background information that may be relevant to the behaviour on a particular day

Simple questionnaire to assess enjoyment and engagement

Video analysis

Module	Description
1. Magic Mirror	At its simplest the chld sees himself on a screen,to get used to his image, when other people move in to the area interaction may occur between them mediated by the sceen. Additional effects can be added such as changing the range of colours, different degrees of interaction to enhance movement and co-ordination
1.1 Simple Mirror	
1.2 Wobble effects	
1.3 Glowing	
1.4 Trails	
1.5 Shimmer	
2 Kaleidoscope	A simplified version of the Iamascope using a restricted tailorable colour palette. The circular images responds to simple movement to develop understanding of cause and effect, and for motor control
3. Spots	The chld interacts with a series of spots on the image, when he moves his arm over a spot it disappears and a digital sound provided.This will aid movement, co-ordination (crossing the mid line), concentration. Other versions can be used to facilitate competitive and co-operative play
3.1 Chase the spot	
3.2 Stepping Stones leading	
3.3 Stepping Stones to follow	
4. Balance board	A wobble board is used to encourage balance , motor control and concentration. Balance is rewarded by increasing the complexity of the projected image (rotating cogs)
5. Rocking chair	Moving away from a virtual interface, the rocking chair can be used as an input device to effect change on the screen or effect change in the auditory environment
6. Sound Fun	Tonal variation and vocalisation is encouraged by providing visual feedback, for example by animating circles on a screen when the pitch is higher
7.Timetable	A virtual timetable, with user definable symbols and activities is being incorporated into the room, to provide a link with other school activities and provide a visual display and reminder of what is happening during the day
8. Tailorable lighting	Children react to colour in different ways, and colour has different mearnings for different children. The lighting of the room can be adjusted to meet the preferences

Table 1:Descriptions of Interactive modules

From our pilot study we are aware and that issues beyond our control (such as problems on the way into school, changes in medication) may overwhelm any beneficial effects of our environment, and that it may be difficult to deduce level of engagement from observed behaviour for example self stimulating behaviour may be attributed to interaction with the display, expressions of pleasure may be due to stimuli that we have overlooked or that have arisen in other contexts

Conclusions

In this paper we have summarised the design and installation of a tailorable polysensory environment for children with autistic spectrum disorders designed specifically for mainstream schools. From our initial pilot study, and through inviting others to look at our work we believe that we have found an opportunity to enhance the provision of resources for children with ASD.

Facilitating Communication, Teaching and Learning in Children with an ASD: Project Spectrum,
Woodcock, A. and Woolner, A. (2008),

Development and Learning, IEEEE 6th International Conference

The Design and Ergonomics Applied Research Group The Design and Ergonomics Applied Research Group

Coventry School of Art and Design Coventry School of Art and Design

Abstract - This paper describes the approach taken to, and the design and evaluation of a low cost, tailorable, polysensory environment for children with an Autistic Spectrum Disorder in mainstream schools. The results of the qualitative evaluation, undertaken over a six week period, show benefits in terms of the communication and engagement of the
children. The implications of these are described in terms of the wider need for tailorable environments, teaching and learning experiences to enable all children to achieve their full
potential.

INTRODUCTION

This work takes place against the backdrop of worldwide increases in the incidence of autistic spectrum disorders (ASDs), recognition that children with ASDs benefit from early intervention [1], that computers may be particularly useful to those with ASDs [2], and a growth in the imaginative and creative use of interactive and reactive media in the design
of inclusive spaces [e.g. 3, 4]. Superimposed on this are UK's policies regarding inclusion of children with Special Educational Needs (SENs) in mainstream education [5] and
the Building Schools for the Future initiative [6] in which all secondary schools will be rebuilt or refurbished in the forthcoming decade.

II. PROJECT SPECTRUM (PS): AIMS

Project Spectrum (PS) was funded by the Arts and Humanities Research Council (UK) to nurture the engagement of children with ASDs through the use of digital technology.

Its primary aims were to:

1) Understand the requirements of autistic children, their teachers and carers.

2) Develop a general purpose methodology enabling such requirements to be captured and embedded in software design.

3) Develop an adaptable, interactive digital environment, tailorable for young people with an ASD.

4) Develop a generic evaluation methodology to assess the extent to which the environment meets the needs of the primary and secondary users.

Secondary, and no less important aims included the need to;

5) Raise awareness of the potential of design to contribute in a useful and meaningful way to the quality of life of excluded and disadvantaged groups.

6) Raise awareness of autism in the UK.

7) Contribute to the advancement of user centred design and educational ergonomics.

III. DERIVING USER REQUIREMENTS

In line with a user centred design philosophy which places the primary users' needs at the heart of the process, the first stage of the research concentrated on eliciting user

requirements for children on the autistic spectrum. This was undertaken through internet surveys (with 500 respondents - parents and children at the high end of the spectrum), semi structured interviews with parents and those at the high end of the spectrum, observation of children playing in current environments and day-in-the-life diaries (completed by parents) – which captured what it means to have a child with autism or to have an ASD. From this, Jackson [8 and 9] developed a set of requirements which allowed the designer to produce a series of interactive modules to address the triad of impairments [7] i.e. in social interaction, communication, and repetitive, stereotypical behaviour.

The PS environment aimed to enhance each of these in different ways; social interaction – through providing different ways of interacting with others (ie via a screen), communication – through games which were activated by vocalization, and through the provision of one–to–one focused experiences, and improving co-ordination through physical activities (in which movement sensors triggered changes on the screen). The designer needed to

1) Accommodate for varying degrees of hyper/hyposensitivity in each sensory system, which affects how much stimulation is required and the response to the stimulation. Whilst some users might require a moderate level of sensory input in order to stimulate them, others demand higher levels of input to even get their attention. Therefore, the system needs to be tailorable to the sensory needs of the individual;

2) Avoid certain materials/objects such as those with moving, edible, destructible parts or those known to trigger adverse reactions (e.g. colorants, certain plastics) because children with an ASD are sensitive to a wider range of inputs (such as smells, flicker of lights and fans in projectors) and will use (and) destroy objects e.g. biting into microphones or pulling apart toys;

Address both ends of the spectrum, by providing an appropriate levels of complexity to make the experience fulfilling, yet neither too demanding or simple;

4) Build in repetition (which provides comfort and security) whilst allowing for new avenues of behaviour.

IV. BUILDING THE PS ENVIRONMENTS

In terms of positioning PS (i.e. understanding what type of artifact should be built and where it should be placed), the most important information was gathered from the children and the experiences of parents who took their children to multi sensory environments, and who completed the day in the life diaries.

Understanding autism as a day-in, day-out condition, requiring constant care, attention and supervision, required a solution that could not only be tailored to meet the needs of all children on the spectrum, but one that was going to be accessible on a daily basis to as many children and their parents as possible. We did not want to create an elitist installation, but a useful experience which could be accessed regularly as part of a daily routine. Therefore, PS had to be designed for access near to home, and to a wide community [8 and 9].

This was achieved through placing PS in schools. This imposed a new set of requirements, such as the need to use readily available technology and material, rather than develop bespoke hardware that would be time consuming and expensive and adhere to school policy and practice. Given the governments commitment over the next decade to increase the number of children with SENs in mainstream education and rebuild or refurbish a large amount of the building stock, it is essential that state of the art, tailored spaces are provided in schools, based on the needs of the pupils.

Woolner, the designer in the project, worked as an artist in residence and designer in a number of mainstream and special schools to gain first hand experience of the needs of the teachers and assistants, the way children with an ASD used equipment, the way in which an environment (such as that to be provided by Project Spectrum) would be used in schools, and the spaces provided for this type of activity.

Drawing on these experiences, Woolner developed a system based around the used of video cameras for motion tracking, a microphone for audio input, a small lighting desk and light system, a data projector and speakers, and an Apple computer to control and pass information between these. Making this decision has meant that later iterations of the system have been highly portable, and can be quickly set up in a variety of settings. It has also meant that other schools have been able to easily purchase the equipment necessary to run the Project Spectrum modules.

As part of our networking activities – involving the National Autistic Society, local community groups, and LEAs – a mainstream primary school became interested in the project and donated a classroom for the development of PS, for use by children with ASD, one of whom became our prime user and tester.

Essential to the delivery of PS was the use of a large projection screen and suitable throw distance, allowing projection at least 1:1 scale. Large scale projection has proved very effective when engaging the children as opposed to a whiteboard or

computer screen. A bespoke projection screen was built to cover an entire wall of the classroom (see Figure
1). The movement area of the environment needs to match the scale of the projection and provide enough space for the children to move freely and completely interact with the projected modules. Space is also required for the projected throw distance, whether front or back projecting. Delivering the project in a working school meant that rather than having an ideal quiet, child sized space we had a real classroom to transform. It was large, echoey, with a hard floor and walls and at break time filled with the noise of the children. We were also restricted in the physical design decisions we could make; no false ceilings; no removal radiators or pipes, changing light position, or adding screens for cosy corners
where a child might not be seem.

Whilst a 'domestic' version of the system was considered, it was felt that without the correct context, facilitation and environment, children would not benefit in the same way that they would in the Sensory Environment. A portable version of the system has been developed in consultation with a Centre of Excellence for the Teaching of Autism.

V. DESCRIPTION OF THE MODULES

FIGURE 1. EXAMPLES OF PS MODULES

The interface is designed so that on loading, the facilitator (or teaching assistant) can diagnose the system and ensure the technology is working and communicating with the computer. A simple click and point interface is used to select and tailor different modules. These require little training to use. All modules are contained within the same application, each having their own control panel to enabling the setting of various parameters. These default to a 'ready to go' setting, so that facilitator need not spend time on this if they want to just get on with a session – useful when children are impatient. By using sliders, each module can be tailored to the preferences or experiences of an individual child (e.g. in terms of type of music, sounds or colours or their favourite modules), and saved for future sessions. The whole interface is controlled by a wireless mouse, that can be taken anywhere in the classroom, so there is no need for the facilitator to leave the child's side.

12 initial modules have been iteratively developed (using feedback from the teaching assistant and children) to address different aspects of the triad of impairments. The initial module, acts as a large mirror, where the children can get used to seeing themselves, and others and looking at them in the mirror. From here visual distortions are introduced such as wobble and dots – in which, when the child moves, their image can become more or less distorted, enticing the child to move to see the effects. This helps in gross motor skills, and co-ordination. In the next modules, more abstract representations are used triggered by movement sensors, such as the kaleidoscope which require more controlled and coordinated movement (see Figure 1).

Touch the dots is challenging on a number of levels. The child must touch the spot to make it move, change colour or score a point. It can be used to improve coordination (of the whole body or body part), and can also be played co- operatively (in turn taking mode) or competitively, thereby improving social interaction.

Later modules require a greater degree of control, patience and the following of instructions – for example to make projected cogs or circles spin through vocalization. Different iterations of this module responded to sound, volume or pitch. A popular example with the children was to control the movement of the kaleidoscope through their voices.

Levels of tailorability can be added to the system through the use of favourite colours, sounds and images. For example in one of the trials, touching the spots was augmented by the use of different animal sounds which were played when a spot was touched.

Although the modules can be seen to address all the triad of impairments, our main aim was to provide a set of interactive activities which would be engaging to children with an ASD, that they would want to use (and look forward to using), which would be tailorable, and provide in themselves a means of encouraging vocalisation and communication, or provide opportunities for communication outside of the event.

VI. THE EVALUATION

PS was iteratively developed in situ in a mainstream primary school, far removed from the controlled 'laboratory' conditions originally envisioned. A similar rethinking was
required for the evaluation. Evaluating environments for specialised populations is difficult. To gauge the true effects of the PS environment, it was vital to evaluate it in its actual
usage context, as opposed to one that was devised to meet the needs of evaluation. Taking any child into a strange or uncomfortable environment, such as a usability laboratory, could result in unusual behaviour and cause undue distress. This would both invalidate any results and be unethical.

Locating the Project in a mainstream school effectively ground the research in the day to day reality of the children and added constraints to the evaluation. However, in delivering our environment in realistic conditions we were able to demonstrate, and provide a working prototype of how the design principles could be applied. This would be of far more value when demonstrating Project Spectrum as a tailorable environment, that could be applied to a wider audience, with different physical spaces available, than if it had been located in a university based usability laboratory.

Our design had to contribute to the life of the school, be accepted by the children, parents, teachers and support workers and be useful to the range of children who might use it, justify the space usage, be accessible and be usable to occasional, as well as regular users. Taking a holistic approach to evaluation is essential for any intervention (whether a computer based system or an environment). Developing a system that accommodates these wider issues enhances its viability as a long term project that continues to have a legacy once the initial research has been completed, and continues to be used by staff members at the school. Interviews with all these stakeholders over the 10 month spent at the school indicated that the space was valued and that all members of the school has bought into the idea, an saw its potential for use with other children.

The 'formal' evaluation had five aims:

1) To provide formative assessment to inform the design lifecycle. Here the need is to provide material that the designer can use to enhance design of the environment and the digital modules. For example, producing material that will link the environment with other activities within the school; modifying the environment to accommodate suggestions made after regular everyday use.

2) To assess the extent to which the environment and the modules succeeded in nurturing the engagement of children with an ASD by addressing the triad of impairments and providing opportunities for engagement.

3) To contribute a generic methodology which could be used to assess similar environments.

4) To assess the extent to which the modules met the underlying requirements.

5) To provide insight into the operation of the Project Spectrum environment in the wider school environment.

These aims were met using a variety of quantitative and qualitative methods which together form a generic evaluation methodology. A profile of the child's behaviour was established before and after the trials using ATEC [10] and a sensory profile checklist and during the trials through an in-house questionnaire and a diary study. However, given hat

the evaluation would only occur over the period of one term, it was felt (and actually) was unlikely that any significant changes in behaviour would be registered on these scales.

Factors which could influence the behaviour in a certain session were recorded in diaries – for example, if the child was ill, happy/well behaved or distressed prior to, or following the session. The children themselves were unable to complete even the simplest rating scales, but where possible, their comments were elicited directly.

All sessions were video recorded for later analysis using simple, emergent behavioural categories (such as looking at the screen, imitative behaviour). Behaviour was sampled every 10 seconds throughout the 15 minute sessions. The same categories could be used to code all the sessions.

Additionally parents, teaching assistants and teachers were interviewed after the evaluation to establish their views concerning PS and its effect on the children.

The expectation was firstly, that children would engage with the modules, secondly that they would enjoy their sessions in the room, thirdly that there might be a reduction in
the triad of impairments, and lastly that we would be able to show some of these in the evaluation.

VIII. EXPERIMENTAL PROCEDURE

The evaluation occurred in school, with two primary school children formally diagnosed as having an ASD, using the room for 15 – 20 minutes each day, over a period of six weeks, as part of their everyday routine. It was not possible to test the modules systematically in such an environment. The children and teaching assistants/ facilitators were active participants controlling the rate of movement through, and the selection of , the modules. However, all modules were used and tailored to meet the needs of the children. Additionally, as the room was located in the school, we were not able to
control extraneous variables arising in such environments.
These had three effects; firstly making reliable recordings difficult, for example

- due to timetabling, one child could only use the room during the lunch hour (as the room overlooked the playground, there was a high level of extraneous noise),
- adults were given guided tours of the room during sessions, thereby altering the balance of the session
- different personnel worked with the children. They had a different relationship with the child, used the room in a different way, and completed the questionnaires in a different manner

Secondly, we could not control the experiences the children were subjected to outside the room - such as bullying, changes of medication or everyday sensory experiences (such as seeing a disliked colour on the way to school); thirdly, the activities that children engaged in in the room, were built on in other lessons e.g. if problems were found with co-ordination or the naming of colours this might be noted and triggered activities in other classes.

Working in this manner provided a higher degree of ecological validity than would have been possible in a laboratory context. However, it meant that it was difficult to attribute any positive or negative results to the room per se. It may be argued that, for some children with an ASD in particular, being sensitive to, and adapting to their environment is the only way a study can progress.

IX. SPECIMEN RESULTS AND REFLECTION

The results from the video analysis are still being analysed. Given the above, and the need to progress through the modules at a rate dictated by the child (for example, if the child became bored, or did not like a module, this was abandoned without reference to the experimental plan), it is unlikely that any one measure of behaviour will indicate that the children benefited from their PS experience. Behaviours being measured include imitative play, time on task and direction of gaze. More obvious measures, such as smiling and laughing (used with some reliability for other populations) cannot be used because, quite simply, it cannot be assumed that a smile indicates pleasure or is a response to a current (known) stimulus.

Therefore, at present, the benefits children might have derived from their experience of PS, have been assessed using semi structured interviews with the teaching assistants and parents who reported positive changes in the children.

For example, from the parents: "He feels a sense of ownership of the sensory room. He enjoys all the stimulating things, all the technology. He talks about it as if it's his room, and he talks about school in very positive terms, 'my school, my classmates' which is wonderful to hear because he has never found that sort of affinity with the school", and

“He's feeling much more part of the group now, because he's had a safe haven where he can do all the things he doesn't want his peers to know about, where he's not self conscious and he's not embarrassed because he's struggling with maths, but then he can go out and share his strengths with the class. It’s an immense move forward.”

From another parent

“He tells me every night when we go home from school. I ask him 'what have you done today Barry?' He told me the names of the two of the other children who came into the sensory room with him and then he said kaleidoscope and colours. And when I asked the next day, they had done kaleidoscope and coloured spots with two other children. So what he told me was right, but I thought I'd better check, and it was right! I thought that was great, that's a positive for me because he never tells me anything about anything. He's started to now. He only started to speak last year. 'I've been in the sensory room today mummy,' he says, which is a lot of words compared to what he used to say. Now that's great for me”

Autism support worker on using the sensory room

“It's been a real help for me when working with the children. Having a room that we can come to that considers their needs is a great bonus. The computer activities have been very popular and have given me a new way to work with the children that I've never had before. I certainly think it should be considered for wider use.”

From these comments would seem that the PS environment, and he activities around it, and the evaluation were of value and promoted engagement of the children, staff and parents

The diaries were used by the assistant to jot down their impressions concerning noteworthy events prior to their session (such as boisterous or uncooperative behaviour) which might effect the session, whether the children remembered the room, looked forward to the session, engaged and enjoyed activities, and the level to which they were tired or excited by the session (care had been taken not to create

modules that would over stimulate the children and make them unmanageable). The diaries showed that the children enjoyed and engaged with most of the modules, and looked forward to
their sessions. Where issues were raised in the diaries with regard to the design of the modules, these were immediately addressed – for example, the competitive or cooperative
elements in one of the games had to be redesigned.

In terms of the triad of impairments, the PS activities provided other means of interaction, and created experiences the children wanted to share (either with the teaching assistant through shared activities or their parents). It provided a focal point for communication and activity based learning. It is hoped that the video analysis will reveal changes in co- ordination (e.g. symmetry of movement)

Additionally, , the teachers understood how PS worked, saw its potential for helping them understand the educational needs of the children, and how they could build on the experiences in other lessons

X. CONCLUSIONS AND RECOMMENDATIONS

The outcomes of the evaluation provided

1) Design recommendations for iterative development, ideas for new modules and links into the national curriculum.

2) An indication of the benefits individual children and their parents gained through experiencing the environment.

3) An assessment of the environment in the school system, and recommendations for the design of future rooms.

Eight months after the completion of the project, the room is still regularly used, and Woolner continues to observe some sessions, meet with teachers, children and parents to gauge how the room is being used and the progress of the children and gain ideas for further modules. Its use has been extended to include any child who may potentially derive benefit from it.

The importance of this project lies not in the instantiation of the requirements in a physical space. Many more such environments have and will be built for children and adults with ASDs and disabilities. However, this project has demonstrated very clearly a need for a dedicated, tailored space for children in schools – where they can feel safe and feel in control of their environment. In the UK, such spaces are not provided in all schools. Technology to support integrated, tailorable environments is available and with the investment in new school builds and refurbishments, it should be a priority to provide such a space in all schools.

However, for children to derive the full benefit from such a space, they also need to have dedicated teachers, who understand their sophisticated needs. [11] argues that learning spaces are very important for children, and that they are imbued with meanings that adults are not aware of. In speaking of their schools environments, primary school children touched on issues of gender, sexuality, bullying and not fitting in, which are not usually heard or acknowledged.

Clearly, more research is needed in understanding young children and the way in which they perceive their school environment. Developing ICT to support teaching and learning is highlighting the fact that we do not know as much about children as we think.

In PS, one child dropped out of the study because he was afraid that he would be perceived as ‘different’ if he was taken into the room. John, on the other hand, used the room to express himself more freely and to not hide his weaknesses (in maths). This in turn enabled him to show his strengths when he was back in the classroom.

In conclusion, we would argue that the experience of developing technology for children with ASD, in and for teaching and learning environments is possible, but challenging. We have found that in designing for the least able, we may benefit the wider population.. All children could benefit from a PS space and individualised teaching, tailored to meet their specific needs.

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Applying the Hexagon-Spindle Model for Educational Ergonomics To the Design of School Environments for Children with Autistic Spectrum Disorders, Woodcock, A., Benedyk, R. and Woolner, A. (2009),
Work, 32(3):249-59

Abstract

Schools and other educational environments beyond serving as the primary work places of children provide the backdrop against which formative emotional, psychological, cognitive and physical development takes place. However, ergonomists have paid little attention to the design of these environments, the interactions within them or their organization from a child's perspective. Children with special education needs, such as those with hearing or visual difficulties, cognitive or social disabilities, or even those with different learning styles may be placed in mainstream schools ill-equipped to suit their needs. Rather than retrofitting classrooms as children with different requirements enter the school, a ground-up approach could be taken to create effective educational environments based on an understanding of the learning tasks to be supported, the learner characteristics and the facilities and interactions needed to effect task completion. The application of an holistic ergonomic model, such as the Hexagon-Spindle model [1 and 2] provides a means of systematically considering the variables which need to be included in the design and evaluation of such environments. This paper presents a case study of the application of this model to the design of low sensory classrooms and interactive learning experiences for children with an autistic spectrum disorder.

Keywords: learning environments, children with special educational needs, ergonomic model

1. Introduction

Benedyk, Woodcock and Harder [1, 2] have outlined a model that may be used to unify and organize research and practice relating to the design of learning environments. Generic ergonomic models have been used successfully in other organisational contexts e.g. [12, 16]; as such there is a precedent in assuming such a model may also add value when applied to educational contexts. This is important, at least in the UK, where the design of educational facilities is being reconsidered following the former Chief Inspector of Schools' (UK) statement [24] that schools and the education they deliver are no longer fit for purpose. The current educational system and, in some cases, Victorian building stock are failing to provide a satisfactory experience for a range of children and their teachers.

At a grassroots level, both teachers and pupils exhibit signs of dissatisfaction with their environment. For teachers, dissatisfaction and stress may be shown in high absenteeism, rapid staff turnover, low retention rates and work related stress. School pupils can suffer similar stresses whilst negotiating their work (learning) in the very same environment, but may be ill-equipped to understand or effect the necessary changes required to improve their conditions. It may be argued that such students are left with few options – at best they are petty breakers of classroom authority (they may day-dream or otherwise fail to engage productively), at worst they may truant (truancy rates run at between 4-48% in secondary schools in London [6]) and indulge in anti–social or anti-establishment activities such as bullying and arson (20 schools are damaged or destroyed each week in England and Wales through arson attacks [18]). Among more mature learners, the same stresses may lead instead to an opting out of the learning process. When an environment fails to support its users in the tasks they need to perform, in no matter what industry, cracks are evident at all levels of the organisation, and may affect all stakeholders. This applies no less to education.

At a policy level, the UK is embarking on activities to improve the fit of educational environments to their young users. [5]. For example, there is an ambitious, nationwide school rebuilding programme (Building Schools for the Future), and there are moves towards inclusion and curriculum change (e.g. Every Child Matters). In parallel, there is more emphasis on individual needs among learners. For example, all 7 years olds are not the same. They might excel in different areas - such as arithmetic or art - and come from different socio-economic backgrounds that will profoundly affect their attitude to learning. It is only relatively recently that we have tried to apply with any degree of sophistication, information about different forms of intelligence and learning styles to the design of learning material and experiences. These have resulted in best practices in action learning, where different teaching styles and learning packages are developed - sometimes on a needs-must basis - to suit the needs of the learner.

However, there is a danger that without a means of integrating previous research and best practice, the multitude of factors that influence the child 'as learner' - from furniture and buildings, to teaching style and social relationships, from local and personal culture to facilities management - might never come together to produce an effective learning environment. One such way of achieving this might be through the application of an holistic model of educational ergonomics.

If a learning environment or package can be tailored to enable one learner or a group of learners to achieve their potential though understanding the factors that influence successful task completion, then arguably, it is possible to optimise these factors to create an effective learning environment for all. This requires taking the knowledge acquired in one school or for one set of learners and extending this to other areas and types of learners. However, to do this requires a systematic representation of the parameters – the development of a shared framework, knowledge base and language. An holistic, generic model would need to be sufficiently adaptable to deal with different types of learners, learning environments and interactions and provide a means of capturing and interrelating these factors. It should be applicable to traditional and virtual classrooms, individual and group work and the various tasks the learner engages in in his/her quest for knowledge – listening, experimentation, skills practice, information searching and reportage - wherever and however this is undertaken.

Two such models have been developed that might provide opportunities for this synthesis – Smith's social cybernetic model [19] and the Hexagon-Spindle (H-S) model developed by the co-authors. One way of testing the efficacy of models is to look at the extent to which they explain, integrate or provide new insights into previous research. The second is to prove their validity in the field.

This case study considers the application of the H-S model to the design of one particular learning environment; for children with one form of special educational need, autistic spectrum disorders (ASD), who may be placed in mainstream school environments totally incompatible with their individual requirements. This illustrates, firstly, the range of issues which need to be addressed in designing and evaluating educational resources, and secondly provides a working example of the way this model could be applied to real-world situations. Prior to discussing the case study in detail, a brief overview of the model is presented, although the reader is encouraged to look at [2] for a more detailed description of its development.

2. Overview of the Hexagon-Spindle (H-S) Model of Educational Ergonomics

The Hexagon-Spindle (H-S) model of Educational Ergonomics is an adaptation of the Concentric Rings model of ergonomics [3 and 9] which places the learner at the centre of the learning task (see Figure 1). In the case of schools, taking children as the main workers emphasizes the need for pupil-friendly environments and activities that are properly scaled and attractive to that user group, that are designed with an understanding of the child's perception of the world and developmental needs. The model makes explicit the fact that any learning interaction undertaken in fulfillment of a learning task may be influenced by a number of factors – although it should be stressed that not all of these will be of equal importance or relevance to each task. A task may be specified as a piece of work undertaken to achieve a particular learning goal. Its successful completion may require the student to interact with materials, equipment, teachers and peers, adopt unfamiliar working behaviours, and navigate the complexities of the school organisation. The H-S Model provides a means of categorizing these issues and showing where conflicts can occur (see [2] for more details regarding this).

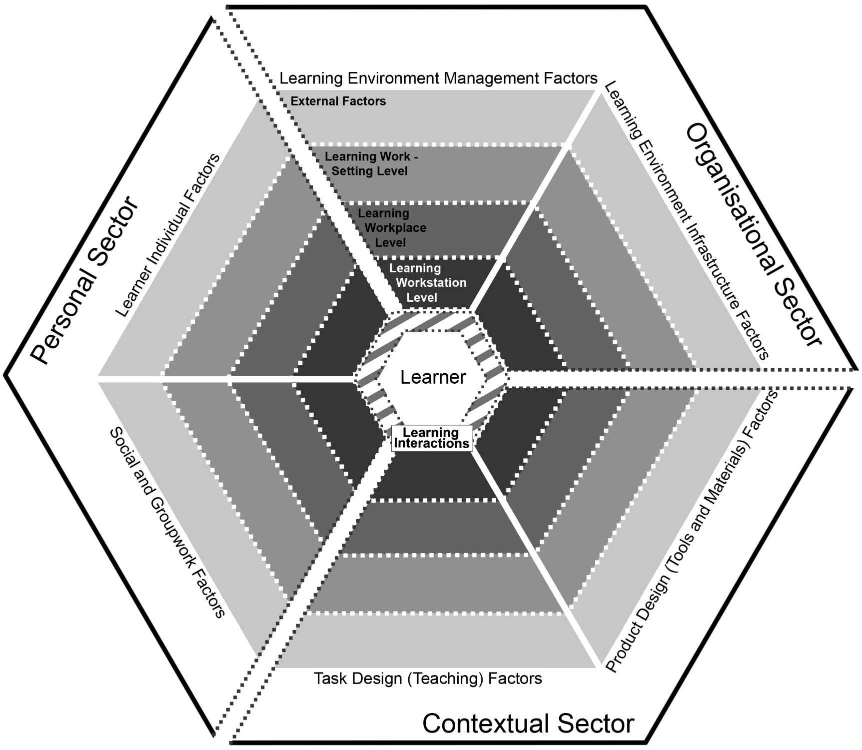


Figure 1: Hexagon-Spindle Model of Educational Ergonomics

The child's school day consists of a series of learning tasks, each requiring the use of different resources, environments and interactions. These tasks can be depicted as a series of hexagons along a time-based spindle (see Figure 2), with learner's individual characteristics remaining fairly constant throughout the day.

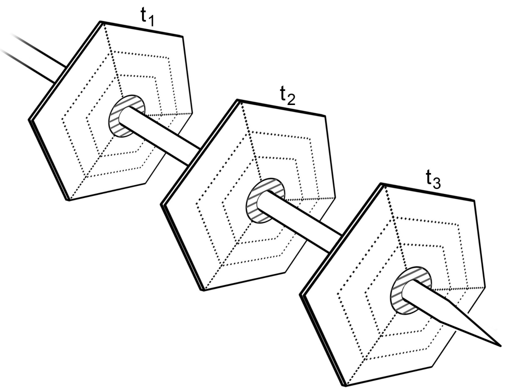


Figure 2: Depiction of build-up of learning tasks on the Spindle

It is believed that the H-S model will provide opportunities for ergonomists to become involved in the design of learning environments by providing the holistic overview sometimes lost in planning stages and a more structured approach to the consideration of the human factors that effect leaning interactions. This is illustrated in the rest of the paper using as a case study, the design of a low sensory classroom and interactive modules for children with an Autistic Spectrum Disorder (ASD). The low sensory classroom would provide the larger work environment for the child and the modules a set of pleasurable, informal learning experiences.

3. The Educational Needs of Children with an Autistic Spectrum Disorder (ASD)

Estimates of the incidence of autism in the UK vary from 1:2500 to 1:1000. Autistic Spectrum Disorders (ASDs) may be seen as just one condition, with different levels of severity, or a series of disorders which have been grouped together because of the types of behaviour exhibited (the 'triad of impairments' [20], in the areas of social interaction, communication and imagination). Importantly, those with an ASD vary in the severity and manifestation of the condition. For example, if it is noted that children with an ASD exhibit sensitivity to colour, the precise colour will vary from one child to another. This means that any learning interaction facility has to be designed around the individual needs of the child, and an understanding of their requirements for the task, as well as all the factors that impinge on learning interaction success.

Looking at the requirements of the children first, children with an ASD exhibit a set of behaviours that differs from the norm [13] such as difficulty integrating some or all sensory experiences (smell, taste, touch, movement, body awareness, sight, sound and the pull of gravity). It is the integration of these experiences that provides the foundation for productive contact with others and the environment. The most effective time to mediate a breakthrough in these patterns is in early childhood. Examples of current approaches include Snoezlen rooms [14], the SonRise programme [15] or the use of robots [4].

UK educational policy recommends that children with an ASD should be accommodated, where possible, in mainstream schools. Observations of the facilities available in some schools reveal little attention has been given to providing effective ASD environments. This may be due to lack of resources (time, staffing, finance and suitable equipment) as well as a lack of understanding of ASD. Where parts of the school environment are too noisy, bright, loud, unstructured or confusing, children (with an ASD or not) may be unable to cope and derive little benefit from going to school.

In designing ASD facilities the challenge was firstly, to provide an affordable, easy to use, manageable system and environment that had sufficient tailorability to accommodate children at different places of the spectrum, and secondly, to develop tailorable, informal learning experiences. These had to allow skill acquisition in those areas most needed by a particular child, integrate with more formal learning experiences (such as literacy, physical education, 'quiet time' and co-operative play) and address the difficulties in the processing of perceptual, social and cognitive information that lead to behavioural problems among ASD children (e.g. short attention spans, lack of curiosity, limited patterns of play and communication).

A 'one size fits all' educational environment was not considered appropriate due to the potential wide range of needs that had to be accommodated, and the difficulty of identifying those needs correctly. Rather, we tried to determine the range of tailorability that had to be accommodated. Therefore a simple lighting system was installed that would enable the room to be flooded with favourite colours; a sound system was provided that would enable favourite sounds/music to be uploaded. A series of multimedia modules were developed that we hoped would be sufficiently engaging to entice a child with an ASD to interact with the material provided. In this case the interaction itself would provide opportunities for learning and skill acquisition.

The following sections describe how the H-S model may be used to represent the different factors at every level that had to be considered in the design of the facility (known as the Project Spectrum [PS] room), and its utility in organizing a structured evaluation program to measure both the effectiveness of individual modules and the operation of the classroom as part of a mainstream school.

4. The Hexagon- Spindle Model and the Development of the Project Spectrum Environment

The overall approach to the design of the Project Spectrum (PS) Environment has been previously described [21]. A picture of the sensory requirements of children on all places of the spectrum was ascertained through an internet survey and follow up interviews [10, 11, 22 and 23]. This provided details about the range of sensory needs the environment would have to accommodate. In terms of the H-S model many of these issues would fall into the central hexagon as learner characteristics.

Observational studies and detailed interviews with parents and 'day in the life' diaries provided a rich picture of the way in which ASD effects everyday life – from the need for routine, to family organization, the effects of visits to interactive environments. This highlighted the need to take into account a wider range of factors than just the experiences gained in the educational setting (see Figure 3). These are found in the outer levels of the H-S model.

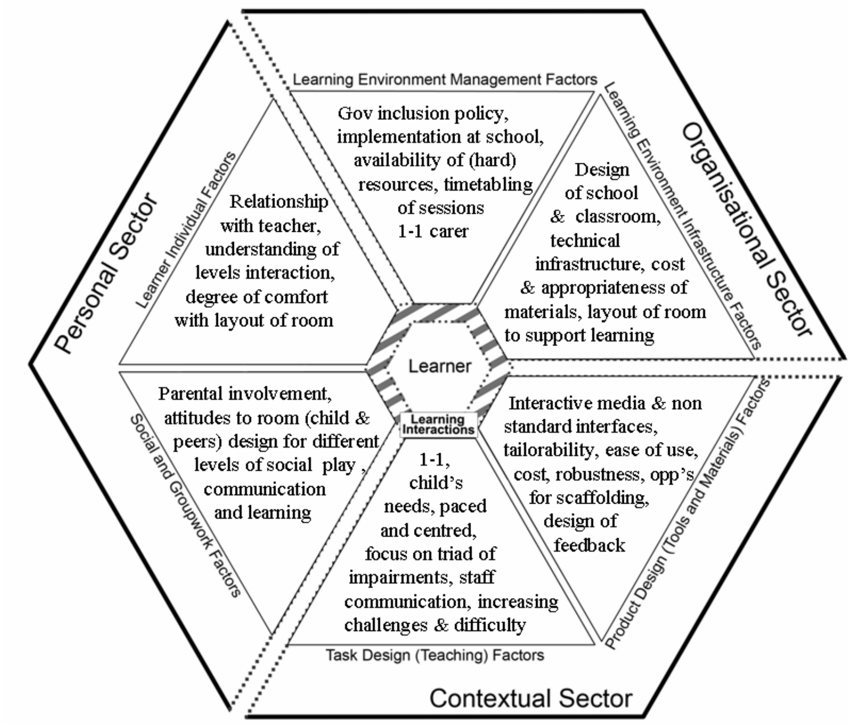


Figure 3: Issues from Project Spectrum mapped on to the Hexagon Model

At the start of the project we planned to develop a suite of isolated, interactive, computer driven modules. Each would be engaging, pleasurable and address one of the triad of impairments (such as co-ordination skills). They would be used within a special configurable classroom. Here, one or more children (with or without an ASD) could work on their own, in groups or with an adult. They would feel safe, and the environment would not inhibit learning (e.g., through the provision of tailorable lighting, configurable work areas and appropriate floor and wall coverings).

<insert Figure 4 here>
Figure 4: The Project Spectrum Room and Modules

Ergonomists would argue that that if you design for the smallest in stature, weakest in strength or least skilled then you begin to have an environment suitable for all. PS was about engaging a disadvantaged and disenfranchised section of the school population. In doing this we discovered the range of issues which should be considered in the design of any learning environment, and that all children should be provided with an environment that enables them to achieve their potential. (The low sensory room and modules were used by the teachers after the project as a workplace for other children with special educational needs). Figure 3 illustrates the holistic nature of our approach. Table1 provides examples of the factors that needed to be considered, at each level and sector, in the design of the room and the interactions.

Design Issues for PS modules in a particular environment (sample factors only)	Organisational		Contextual		Personal	
	Learning Environment Management	**Learning Environment Infrastructure**	**Tools and Materials (Product) Design**	**Teaching (Task) Design**	**Social and Groupwork**	**Learner Individual**
External environment factors important for the design of PS	Inclusion policy for ASD children, need for children to be taught basic skills, rules and regulations and Health and Safety	E-learning, School buildings with potential for ASD room development	Ability to create suitable software that's tailorable, affordable and provides interactive experiences	Recognition of the need to provide ASD children with 1-1 specialist support, and different types of lessons	Parental support for innovation, cultural norms within ASD community for trying new technology	Individual pupil assessment, attainment plans and resource allocation from government eg computers
Learning Work Setting Level for PS	Communication between teachers and TAs, transfer of notes, support for specialist teachers and training of teachers School budget	Support and funds available for changes to the classroom; practicality of changing round facilities and access to facilities.	Durability, cleanability cost, availability of furniture and specialised installations	Scope for innovative practice within the curriculum; adaptability of teaching requirement for ASD pupils.	Buddy schemes for children with ASD	Motivation towards and toleration of novel environments; tolerance of being singled out to use the ASD environment

Learning Workplace Level for PS	Management and design of PS so that it can be used by different members of staff for different types of pupil needs	Type and arrangement of desks, size of room, design of projector, size of dance area and screen	Workplace configurable for different forms of learning; ease of adjustments; flexibility	Capability to link the software to curriculum objectives, and build up levels of difficulty.	Facilities for co-operative and competitive play	Relationship between the TAs and the learner; Sensitivity of teacher to needs of the pupil. Ability to follow instructions
Learning Workstation Level for PS	Allocation of sufficient suitable staff to meet 1:1 requirements for these pupils	Non-standard workbooks, modules, specialised games	Nonstandard interface based on movement and vocalization	Tailorability of software to gain the interest and tolerance of the child	Interface support for learning through co-operative and competitive games	Interface support for student led progress through the modules
Learner interaction of pupil in PS classroom or with modules						
Learner level for PS	Lack of verbal skills, poor levels of attention, few social skills, poor co-ordinatom and ability to tolerate or engage in social play					

Table 1: Elements of the model analysis applied to the Project Spectrum Environment

At the external level the basic need for the PS room was shaped by government policy on inclusion of children with special needs in mainstream education and a lack of adequate, affordable, tailorable, demonstrably effective provision. Other external factors which shaped the design were the capabilities of new technology to provide interactive, polysensory experiences.

Moving to the learning work-setting level, this equated to a 'traditional' primary school. As such we were required to comply with existing health and safety regulations (e.g. no private areas, where a child might be able to work with an adult without being overlooked) and to work within existing financial and administrative frameworks. Additionally, we had to design activities and software that could contribute to measurable levels of academic achievement and be used by different members of staff, with different children.

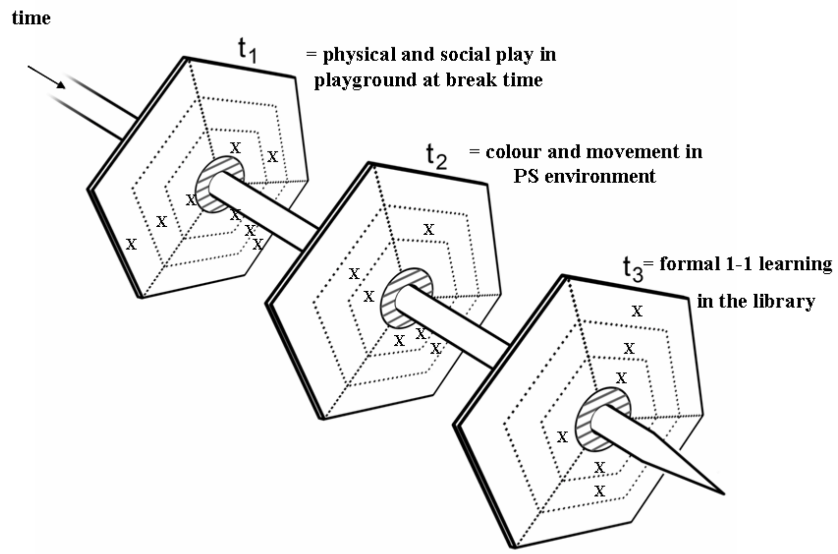
Although the teaching staff, teaching assistant who worked with children, parents, Local Education Authority and the children themselves, all wanted to be involved in the project, we were cognizant of the need to bear in mind teachers' [17] and parents' [8] attitudes towards inclusion and the teachers' level of experience [7]. This is reflected in the individual and parental attitudes at the work setting level. The room needed an adult facilitator to structure the session, act as a guide or playmate, and report on learning achievements and activities to other members of staff, who could follow through on the opportunities. The Management Sector of the model prompts the availability and training of such staff, and the Individual Sector indicates the importance of the relationship between the learner and these staff.

It is not just the design of the physical environment that produces barriers to learning but also, how the learning experience is organized by the school. For example, the movement of the child from one classroom to another, the transfer of personal equipment (see Infrastructure Sector), and the opportunities for staff members to share information about children in the school so that appropriate adaptations can be made (see Management Sector). Such operational factors need to be overtly described through a work-based organisational model that focuses on the factors needing to be addressed for successful task completion. The need to differentiate between these types of factors is catered for by the different sectors in the model.

The learning workplace was the low sensory classroom. This was stripped, and equipped with furniture and places that would enable individual, supervised and joint working. A tailorable lighting system, full size display screen, movement area and six basic learning modules were provided (see Figure 4).

At the learning workstation level, interaction with the learning material was through a non- standard interface based on movement and sound detectors. Whole body, refined movements or vocalizations were used to cause immediate changes in the life-sized display. Modules could be reconfigured to provide opportunities for solo, joint co-operative or competitive play. To be maximally effective this interaction required well-motivated teachers, who would work with the children to lead them to fully explore opportunities provided in each of the modules.

The application of the spindle part of the model was used to depict the school day as a series of tasks, each of which places different requirements on the learner in a different context. For example, the child's session in the PS room would be sandwiched between other activities such as break time (providing opportunities for social play and co-ordination) and more structured learning activities e.g. in the library. Each task is influenced by a set of unique factors that contribute to the effectiveness of the learning (illustrated by the black crosses in the hexagons)



<Figure 5: Spindle model illustrating build up of learning events>

Figure 5 shows that learning tasks are spread across different environments, each of which present a different set of ergonomic requirements. In this figure the unit of time is equivalent to a class period. However, other time units could be used. At this level, the model provides a detailed breakdown of the factors that need to be considered for the design of individual pieces of equipment. In Project Spectrum this level of analysis would provide us with specific details for the interface design (e.g. the degree of sensitivity of the movement or sound sensors)

For convenience, the characteristics of the child are shown as being constant from one event to another. This is an oversimplification. For example, mood, motivation and attention levels may vary throughout the day – so a task producing learning gains in the morning may not be so effective later in the day when the child is tired. Also, the effect of events preceding the task in question need to be considered. For one of the children in our case study, the only time available for her to go into the room was towards the end of lunch-time play. The playground activities she sometimes experienced had a quantifiable effect on her behaviour and motivation to engage with the modules (for example whether she was tired, overexcited, or relieved to escape from boisterous playground games).

From the above discussion it can be seen that a number of factors led to the final decision to place Project Spectrum in a school, and that this decision in itself led to the need to address a wider set of requirements, even prior to the development of specific modules. Table 2 represents a selection of influencing factors, ergonomic issues and possible approaches to a solution for the design of one interactive module (the kaleidoscope module shown in Figure 4, enabling practice of whole body co-ordination).

Levels	External Environment	Learning Work Setting	Learning Workplace	Learning Workstation	Learner
Example of influencing factors	Availability of software and hardware to create bespoke interactive environments	Dedicated teacher not always available to run the session	Room has high levels of natural day light and noise from the adjacent playground	Size of display in kaleidoscope module	Poor co-ordination skills and attention span
Example of ergonomic issues	Lack of stakeholder awareness of the possibilities of innovative systems to be used in schools	Children with an ASD need regularity, and also become impatient with delays	Display screen cannot be seen, noise is distracting	Child was fixated on pixels rather than the higher level gestalt of the display, and moved to touch these rather than interact with the display as a whole	Increase level of attention to the interface so that co-ordination skill might increase
Possible ergonomic approaches to solutions	Use this ‘attractive’ module to attract attention and buy in of key personnel to develop more modules	Make the set up easy to use, train more than one TA to use the system, and to be acquainted with child	Make blackouts for the windows of acoustic insulating material	Incorporate a dance floor with black board which clearly signalled where activity could take place	Ever changing display – or make display tailorable to the interest of the child

Table 2. Illustrative example of the application of the Hexagon-Spindle model to the design of an interactive module promoting co-ordination and co-operative play

Versions of the PS classroom and the modules are subject to ongoing iterative development and qualitative evaluation. The classroom remains operational one year after the close of the project and is being used by a wider range of children and teachers. The general requirements that emerged during the project are being used to develop additional modules and classrooms.

5. The Hexagon - Spindle Model and the Evaluation of Project Spectrum

The evaluation of the overall project was complicated, because it needed to consider the effectiveness of individual modules for engaging children and helping them acquire new skills, and the wider effectiveness of the low sensory classroom in terms of the operation of the whole school. The H-S model shaped the structure of the evaluation and ensured that each group was asked pertinent questions. Examples of the type of methods used at each level are shown in Table 3. A summary of the operation of the evaluation strategy and the results is provided below.

Design Issues for PS modules in a particular environment (sample factors only)	Organisational		Contextual		Personal	
	Learning Environment Management	**Learning Environment Infrastructure**	**Tools and Materials (Product) Design**	**Teaching (Task) Design**	**Social and Groupwork**	**Learner Individual**
External environment factors important for the design of PS	Semi structured interviews with head teacher, national agencies to evaluate the extent to which the room met the wider needs of effective learning envrionments		Demonstration of the room to peers at conferences	Informal iterative evaluation with TA and other teachers to assess the extent of fit with QAA objectives	Informal interviews with parents of the children involved in the study. Checklists to measure behavioural change during the course of the trials	
Learning Work Setting Level for PS	Semi structured interviews and observations with teachers to assess the operationalisation of the room in the school				Semi structured interviews and observations with teaching staff	
Learning Workplace Level for PS	Observational studies to show the use of the room over the course of the day. Informal observations and interviews with teaching staff to assess the usability problems and scope for design improvement		Usability assessment from video analysis and diary observations	Informal interviews with TA and teachers directly involved in the room and working with the children.	Interviews with parents to assess perceived change in the child over time eg increased talk	Diary studies, rating scales etc to show behaviour individual sessions filled in by TA
Learning Workstation Level for PS	Observational studies and interviews with key staff		Video analysis focusing on usability problems	Informal interviews with TA regarding opportunities for scaffolding etc	Video analysis of sessions to identify changes in behaviour eg time on task, levels of co-opeative play and imitative behaviour	
	Learner interaction of pupil in PS classroom or with modules					
Learner level for PS	Students were mostly unable to provide reliable feedback or commentary on their enjoyment or otherwise of the modules					

Table 3: Evaluation methodologies employed in Project Spectrum

Woolner worked as a creative practitioner/designer at the school and was able to evaluate the success of the PS room through his day-to-day interactions in the school and by holding regular informal interviews with key members of staff. A formal evaluation was conducted over 6 weeks with three children with ASD spending up to 20 minutes in the room, working through modules at their own pace. Each child was assessed before, during and after the evaluation using standard and purposely developed assessment instruments. Daily diaries were kept by the teaching assistant to record perceived attitudes of the children towards their experience. These were cross-checked with a video analysis of the sessions to inform the iterative design of the modules. Some of these findings were used in realizing the need for a spindle approach to representing the school day.

The three children were not able to directly contribute to the evaluation as they had poor communication skills. Also, their experiences were influenced by uncontrollable variables (such as changes in medication, exposure to upsetting stimuli on the way to school, bullying), which meant that it was difficult to establish whether there had been a quantitative improvement in behaviour as a result of our intervention. We developed behavioural measures such as time on task, or engaging in imitative behaviour, which we hoped to correlate with other data to show that there was an overall benefit for the children and their carers.

The inability of the children to verbalise or show whether they had derived pleasure from their experiences in the PS room put a greater importance on the qualitative feedback provided by parents, teaching assistants, teachers and school manager. Prompts for such feedback were derived from the H-S model, thus ensuring issues at both the macro and micro level were pursued. The room was positively viewed by all groups –with children perceived as enjoying and engaging in the interactive sessions and the tailored 1-1 teaching. They were willing to try new experiences and engage in social play. Two parents noted improvements in behaviour and an increase in verbalization – in which the children talked excitedly about their sessions in their new room – and this was seen as an important benefit.

6. Conclusions: The Future of the Hexagon-Spindle Model of Educational Ergonomics

This paper has illustrated the way in which the Hexagon-Spindle Model can be used to describe the design and evaluation of learning environments. The case study has been used to illustrate retrospectively how the model could benefit the design and evaluation of educational environments. It is argued that any learning interaction has to be designed around an understanding of the requirements of a particular child or group of children – the users of the learning environment and the factors that effect learning interactions on a specific task.

To take the Hexagon-Spindle Model forward, three steps are envisaged: firstly to convince architects and planners to apply such a model to the pre-concept stages of school planning, where it could be used to co-ordinate, integrate and focus the viewpoints of stakeholder groups on the needs of the child; secondly to use the model to conduct a meta analysis of research related to the ergonomics of school environments and set out a road map for future research; thirdly, to look at ways in which this model can be used to integrate research conducted in the design of educational materials and environments in different disciplines to inform the future design of effective, pleasurable student-centred spaces and resources.

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